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Oxford
from Williams

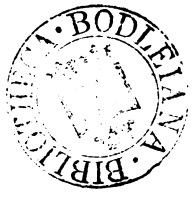
A PORTION

OF THE

PAPERS RELATING TO THE GREAT CLOCK

FOR THE

NEW PALACE AT WESTMINSTER,



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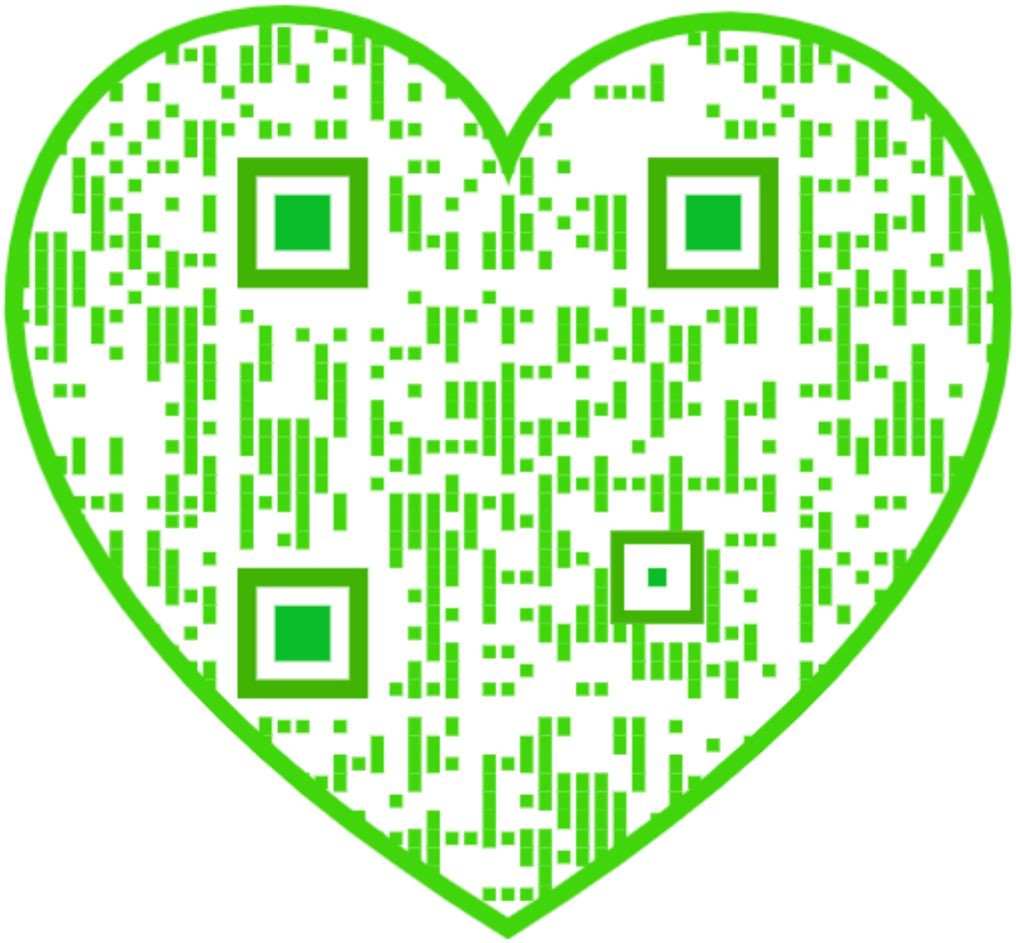

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INTRODUCTION.

INTRODUCTION.

HER Majesty's Government having determined to rebuild the Palace at Westminster, to restore the old Clock Tower, and to place therein as good a clock as, in the present state of the art, could be made, the architect, Mr. Barry, with the approbation of Her Majesty's Commissioners of Woods and Forests, applied to Mr. Vulliamy for a specification and plan of such a clock as he should conceive to be best fitted for the purpose. These, under certain conditions, which were agreed upon, Mr. Vulliamy undertook to prepare.

Some time afterwards, Lord Viscount Canning, then Principal Commissioner of Woods and Forests, applied to Mr. Airy for his advice upon the subject; and Mr. Airy recommended that Mr. Dent and Mr. Whitehurst, of Derby, should also be applied to, which was done. Subsequently, however, Mr. Vulliamy declined to compete: but, according to his engagement, he furnished Mr. Barry with the information which he required, in reference to the preparation to be made in the tower to receive the clock. He also supplied for the Commissioners of Woods and Forests an amply detailed specification for the clock, as he proposed it should be made, illustrated by 36 very large drawings. A long correspondence then ensued, which ended in Mr. Vulliamy entirely withdrawing from the competition. That Mr. Vulliamy should have found himself compelled by circumstances to act in this manner, after the time spent, and the expense incurred, in preparing these plans and specifications, must appear extraordinary to any person inquiring into the subject; and Lord Brougham, who has taken great interest in all that relates to the Houses of Parliament, moved for copies of the correspondence, which were ordered to be laid on the table of the House.

Mr. Airy, on the receipt of Lord Canning's letter, seems at once to have determined—

1st. That he would invest himself with full and complete authority in all matters connected with the clock for the New Palace at Westminster;

2nd. That Mr. Dent, and no other person, should be employed to make it;

and to accomplish this end has been the aim of all his correspondence, even to the last letter but one which he wrote in the matter, wherein he objects to Messrs. Thwaites and Reed being admitted to compete; while Mr. Vulliamy and Mr. Whitehurst have been brought forward merely to keep up the form and appearance of a competition.

That these assumptions are well founded may be gathered from a perusal of the documents which are now reprinted, and the observations which accompany them.

Mr. Dent, in his application to the Commissioners of Woods and Forests, for permission to compete for the clocks for the New Houses of Parliament, refers to the report of the Gresham Committee on the building of the Royal Exchange; and commences by quoting a remark of Mr. Airy, who is stated to have said of the clock erected by Mr. Dent, at the new Royal Exchange, "*I have no doubt but that it is the best public clock in the world;*" and then proposes that he (Mr. Dent) should be employed to make the New Palace clock, subject to the approbation of the Astronomer Royal himself.

Mr. Airy, in his reply to a letter from Lord Canning, after recommending Mr. Dent and Mr. Whitehurst, and specifying the mode in which the making of the clock at the Royal Exchange had been conducted under his own immediate direction, offers to superintend the clocks that may be required for the new building in a similar manner; and, without waiting for his offer to be accepted, transmits a sketch of the conditions to which the maker of the clock ought to be subjected, for the properly carrying out of his, Mr. Airy's, views: and concludes by the recommendation to transmit proposals (including his conditions) to Mr. Dent; and advises, if his price should not be excessive, to employ him, without inquiry of any other makers.

Further, in the same letter, Mr. Airy exhibits an unjustifiable prejudice against Mr. Vulliamy, as is clearly evinced by the unfounded attack which he has made upon his private character in an official letter to a high public functionary. Moreover, so early in the proceedings as the 22nd July, 1845, and before Mr. Dent had even applied to be a competitor, Mr. Airy had written the following letter to Mr. Dent:—

"Sir,

"Royal Observatory, Greenwich, July 28, 1845.

"In the event of my being consulted by the Commissioners of Woods and Forests, "in regard to the erection of a first-rate clock in the New Houses of Parliament, I shall "state, without hesitation, that I believe the clock which you have constructed for the "Royal Exchange to be the best in the world as regards accuracy of going and striking; "and that I consider you the most proper person to be entrusted with the construction of "another clock of similar pretensions.

"I have, &c.,

"Mr. E. J. Dent." (Signed) *G. B. Airy.*"

The foregoing letter, and a variety of facts (which will be found in the following reprint of a portion of the papers laid on the tables of the two Houses of Parliament), so clearly point out the line of conduct which Mr. Airy was predetermined to adopt, that Mr. Vulliamy resolved to retire from a competition, which was to be subjected to the unrestricted control of Mr. Airy alone.

The very irregular manner (in reference to the dates of the documents) in which these Parliamentary papers have been printed (arising, no doubt, from the mode in which they were returned), renders the perusal of them extremely inconvenient; for some of the papers, Messrs. Dent's and Whitehurst's tenders, estimates, and specifications, which were moved for by Lord Brougham on the 31st of May, were withheld (as is reported) by the Astronomer Royal, and were not returned to the order of the House, until moved for by his Lordship a second time, on the 21st June following. It is particularly deserving of notice, that the first part only of the letter (dated 15th March, 1847) from Mr. Dent to Mr

Philipps, was included in the first return; while the second part, "*explanation of drawing* '*A*,'" (which appears at p. 42) was not laid on the table of the House until subsequently called for by Lord Brougham. The identity of the dates of these two papers proves that they are part of one and the same document. One of these papers, namely, the letter of the 20th June, 1846, from Lord Canning to Mr. Airy, was not produced, until Lord Brougham made his third requisition, in December, 1847.*

A careful perusal of the papers, in the order in which they are here presented, irresistibly leads to the following conclusions:—

1st. That Mr. Airy was, throughout, not only very strongly biassed in favour of Mr. Dent, but had, from the first, made up his mind that Mr. Dent, and no one else, should make the clock.

2nd. That Mr. Vulliamy was, under the circumstances here detailed, fully justified in declining to compete, if Mr. Airy were to be constituted sole referee, and all proceedings connected with the clock placed under his absolute control.

If these conclusions appear to be justified by the contents of the correspondence, perhaps it may not be too much for Mr. Vulliamy and Mr. Whitehurst to desire that the whole of the papers furnished by the three competitors, be referred to a committee of scientific men, for their opinion and report.

* See printed Returns of the House of Peers, laid on the table of the House, February 3, 1848.

A PORTION OF THE PAPERS CONNECTED WITH THE GREAT CLOCK.

1844, March 29. No. 1.

C. Barry, Esq., to Mr. *Vulliamy*.

Great George-street, Westminster, March 29, 1844.

Dear Sir,

I SHALL be obliged by your informing me whether you would be disposed to furnish me with a plan for the clock which will be required for the New Palace at Westminster. I propose that the clock should strike the hours on a bell of from eight to ten tons; and, if practicable, chime the quarters upon eight bells, and show the time upon four dials about 30 feet in diameter.

As I cannot undertake to promise that you will be employed to make the clock in question, I beg to know, in case you should be disposed to furnish me with the information which I require, upon what terms you would do so, both in the event of your not being employed, as well as in that of your being appointed to execute the work. I shall require a full description of the work, with all the necessary explanations and calculations, and complete working drawings of the clock and all its parts; also a drawing of the clock as it would be in place in the clock-room; in short, all necessary information to enable any competent person to make it.

I am, &c.,

(Signed) *Charles Barry*.

1844, April 1. No. 2.

Mr. *Vulliamy* to *C. Barry*, Esq.

Pall Mall, April 1, 1844.

Sir,

IN reply to your communication of the 29th ultimo, I beg to say that I am perfectly willing to comply with your request, and make you a plan for a clock, such as ought to be placed in the clock tower now building at the Palace at Westminster, and adapted to answer the required conditions in your letter, namely, to strike the hours on a bell of from eight to ten tons, and the quarters, if it can be so arranged, on as many as eight bells, and to show the time on four faces, about 30 feet diameter; also to furnish you with the necessary specification, calculations, and drawings, including working drawings, and a complete plan and elevation of the clock, representing it as it will appear when fixed in the tower, such as will enable you to have the clock made by whoever you may think proper to employ.

The clock I should propose as fit for the purpose would be very much the most powerful eight-day clock ever made in this country, and I believe in any other, but one which I should have no difficulty in executing.

The dials, 30 feet in diameter, are the largest I am acquainted with, excepting a skeleton dial at Malines, on which the time is shown by only one hand, which makes one revolution in 12 hours. The dial of St. Paul's clock, which is only 18 feet diameter, is the largest in this country that is furnished with a minute hand. A few of the clocks in Flanders strike on large bells, but they require to be wound every day, and in some instances twice in the 24 hours.

To be the better enabled to do what you require, I should go to Paris expressly to examine the Hotel de Ville clock, from which I apprehend some useful information may be gained. I should also examine the clocks at Lincoln Cathedral and York Minster, both which strike on very large bells, particularly in relation to the proportion the weight of the hammers bears to the bells they strike upon. This will be attended with considerable pecuniary expense; moreover I shall have to pay for copying drawings, &c., which it is impossible I could find time to do myself.

I should, therefore, propose, if I am employed to make the clock, to be paid one hundred guineas for the specification, calculations, working and other drawings, which sum, I am sure, will not more than cover my disbursements; but should I not be employed to make the clock, then to be paid an additional hundred guineas for my time and trouble.

To make such a set of drawings, calculations, and specification, &c., as I propose, will occupy some time, and to make the clock will be the work of two years. This is sufficiently accounted for by the circumstance that all the patterns must be made on purpose.

I am, &c.,

(Signed) *B. L. Vulliamy*.

1844, April 10. No. 3.

C. Barry, Esq., to *A. Milne*, Esq.

Westminster, April 10, 1844.

Sir,

OWING to the progress making with the clock tower at the New Palace at Westminster, the time is now arrived when it is desirable to have the necessary specifications, working drawings, and estimates, prepared for the clock, in order that the walls of the tower may be carried up in accordance with the necessary arrangements for the weights and machinery connected with it.

I have, therefore, applied to Mr. Vulliamy, as, in my opinion, the person best qualified to make out such specifications, working drawings, and estimates, to ascertain whether he is willing to furnish them, and upon what terms; and I now beg to forward to you the correspondence which has taken place between us upon the subject, and to recommend that his offer be accepted.

I have, &c.,

(Signed) *Charles Barry*.

1844, April 26. No. 4.

C. Barry, Esq., to Mr. *Vulliamy*.

My dear Sir, Westminster, April 26, 1844.

I ENCLOSE the Government Authority which I have just received in respect of the clock for the New Houses. You will, therefore, have the goodness to proceed accordingly.

Yours, &c.,
(Signed) *Charles Barry*.

1844, April 24. No. 5.

A. Milne, Esq., to *C. Barry*, Esq.

Sir, Office of Woods, &c., April 24, 1844.

THE Board having had under their consideration your letter of the 10th instant, reporting that it is desirable to have the necessary specifications, working drawings, and estimates, prepared for the large clock intended to be placed in the clock tower at the New Houses of Parliament, and recommending that Mr. Vulliamy be employed to prepare such working drawings, specifications, &c., &c., I am, in reply, to convey to you the Board's authority to engage Mr. Vulliamy upon this service, and upon the terms he proposes, namely, to receive one hundred guineas for his time and trouble in completing the before-named service to your satisfaction if he should be employed to make the clock, but if he should not be employed to make the clock, then he is to be paid an additional one hundred guineas for his services.

I am, &c.,
(Signed) *A. Milne*.

1844, April 27. No. 6.

Mr. *Vulliamy* to *C. Barry*, Esq.

My dear Sir, April 27, 1844.

I BEG to acknowledge the receipt of your letter of yesterday, and the copy of Mr. Milne's letter by which it was accompanied. I shall proceed without delay to prepare the plan of the clock for your inspection. It is probable I shall stand in need of some information from you before I can proceed with the detail of the machine, when I will ask you to make an appointment to see me.

I have, &c.,
(Signed) *B. L. Vulliamy*.

1844, May 3. No. 7.

Mr. *Vulliamy* to *C. Barry*, Esq.

My dear Sir, Pall Mall, May 3, 1844.

BEFORE proceeding to make the plan for the great clock for the New Palace at Westminster, there is one point on which I want to consult you. It has been the practice in making clocks of all descriptions, particularly when anything above mediocrity is attempted, to put much superfluous work in them. By superfluous I mean polishing the arbours of the wheels and faces of the pinions, making all the work connected with the striking parts bright, filing up the arms of the wheels and other similar ornamental work, in nowise affecting the performance of the clock. To this there is not any objection with small work, but in the case of large clocks, particularly one of the size required for the Houses of Parliament, this additional work entails a great, and, as far as the performance of the clock is concerned, unnecessary expense. This species of "luxe d'exécution," as it is termed by the French clockmakers, is much esteemed by them, and when clocks are to be enclosed in glass cases, and exhibited like the clocks at the Invalides, the Jardin des Plantes, and the Bourse, it may be all very well, but for any practical use or benefit it is quite useless; for unless a clock is preserved from dirt and damp better than is done in one case in twenty, the greater part of this ornamental finishing is destroyed by rust in a very short space of time.

The Duke of Wellington came to see the clock I made for Windsor Castle; and, the circumstance of there not being any unnecessary work in the clock, met with his Grace's unqualified approbation; but as this is a point on which much difference of opinion exists, I shall be much obliged if you will let me know what your wishes are on that subject, that I may regulate the construction of the clock accordingly.

I am, &c.,
(Signed) *B. L. Vulliamy*.

1844, May 13. No. 8.

Charles Barry, Esq., to Mr. *Vulliamy*.

Dear Sir, Westminster, May 13, 1844.

IN reply to your letter of the 3rd instant, I beg to acquaint you that all the work which you therein term superfluous should, in my opinion, be avoided in the great clock proposed for the New Palace at Westminster.

I am, &c.,
(Signed) *Charles Barry*.

1845, Jan. 13. No. 9.

Mr. *Vulliamy* to *C. Barry*, Esq.

My dear Sir, Pall Mall, January 13, 1845.

HAVING a few days since occasion to look over the papers connected with the great clock for the New Palace at Westminster, I observed a mistake in a letter addressed to you from the Office of Woods, under date of the 24th April last, which I never noticed before, and to which I beg to call your attention.

In your letter to me of the 29th March you very particularly, and in detail, enumerated the services you require from me in reference to the proposed clock, and my answer of the 1st April is equally explicit. In neither is any mention or allusion made to an estimate; but in the letter from the Office of Woods above referred to, the word estimate is incidentally introduced, no doubt as a matter of course. To make an estimate would, until it is definitely settled how the clock is to be made, be quite useless; moreover it would be a work of great labour, occupying much time, and which was not contemplated by either of us.

I thought it right, without delay, to notice the circumstance to you, that it may not give rise to any misunderstanding hereafter.

I have, &c.,
(Signed) *B. L. Vulliamy.*

1845, July 22. No. 10.

G. B. Airy, Esq., to Mr. *Dent.*

Sir, Royal Observatory, Greenwich, July 22, 1845.

IN the event of my being consulted by the Commissioners of Woods and Forests in regard to the erection of a first-rate clock on the New Houses of Parliament, I shall state, without hesitation, that I believe the clock which you have constructed for the Royal Exchange to be the best in the world as regards accuracy of going and of striking, and that I consider you the most proper person to be entrusted with the construction of another clock of similar pretensions.

I have, &c.,
(Signed) *G. B. Airy.*

This letter is a very singular document, and if it be connected with the events to which it alludes (and how else can it be regarded?), it yields a presumption by no means favourable to the Astronomer Royal, as a person to be invested with the absolute power which he would possess as sole referee upon so interesting a matter as the construction of a clock for the New Palace at Westminster.

How far Mr. Airy has shown himself qualified for the high position to which he aspires, certainly is not to be gathered from this letter, which, having found its way into the public records, is open to the criticism of any person interested in the matter. It is, indeed, impossible to read this letter, and to weigh the pledge which it offers, nay assures, to Mr. Dent, and consider the writer capable of acting impartially in the matter on which he is to be sole referee—sole judge!

1845, Nov. 14. No. 11.

Mr. *Dent* to the *Commissioners of Her Majesty's Woods and Forests.*

My Lord and Gentlemen, 33, Cockspur-street, Nov. 14, 1845.

I BEG leave most respectfully to inform your Honourable Board, that I am desirous of being admitted as a candidate for supplying the large clock, and such others as may be required for the New Houses of Parliament.

Being unknown, except perhaps by reputation, to your Honourable Board (though employed by the Lords Commissioners of the Admiralty in constructing their clocks for dockyards and marine barracks, and entrusted by them with the care of all their astronomical clocks at the Royal Observatory for 20 years), I request permission to make the following statement in support of my application.

When required by the Gresham Committee to make for the New Royal Exchange a large public clock, the most accurate that art could produce, I found that the want of efficient tools in the clock trade was such as to render the construction of so exact an instrument impossible. I accordingly erected a clock manufactory of my own, at Somerset Wharf, Strand, which I furnished with tools of the first description, at the cost of 2000*l.* There the manufacture is carried on under my personal directions; and I respectfully request a visit to these premises from any gentleman whom your Honourable Board may depute, that he may satisfy himself as to the manner in which the business of clockmaking is there conducted.

The attention, however, of your Honourable Board is more especially invited to the new clock at the Royal Exchange, and a scrutiny is solicited into the precision of its performance. I may be allowed, with all deference to your Honourable Board, to submit the advantages of examining an instrument like this, actually going, over the inspection of a mere design. Again, the models for the several castings are all made, which will occasion a great saving of expense.

I will not presume to trouble your Lordship and the other Commissioners with a tedious and technical detail of mechanism; but in order to verify the excellence of the Exchange clock (the fellow of which I now propose for the New Houses of Parliament), I would refer to the printed report and letters which accompany the present application. The language of the Astronomer Royal with regard to the Exchange clock is, "On the whole, I consider the clock as being highly creditable to the Exchange Committee, and to the clockmaker. I have no doubt but that it is the best public clock in the world." The architect, in a letter in reply to me, writes: "The suggestions and directions which you gave for the preparing of the tower for the reception of the works, weights, and all attached machinery, appeared to be very simple and satisfactory." Mr. George Rennie, the engineer, does me the honour of saying: "The clock is a fine specimen of workmanship, and that you have taken great care in the construction, particularly with the curves of the wheel-teeth and lifting cams."

I trust I shall be pardoned for expressing an opinion to your Honourable Board that the building of the Parliament Houses has already advanced further than is desirable, considering that the arrangements appertaining to the clock have been delayed, and yet remain undecided.

My proposal is, to obtain the sanction of your Honourable Board for erecting the new clocks, subject to the approbation of the Astronomer Royal himself, Mr. Barry and Sir John (or Mr. George) Rennie being referees. In the event of this proposition being approved I feel certain that science, stability of fixing, and engineering, will be united in producing a national monument of finished mechanism and accurate performance; and when I obtain these gentlemen's written certificates, no doubt can exist of my having executed a work deserving the high patronage to which I aspire.

I have, &c.,

(Signed) *E. J. Dent.*

Mr. Dent may have been employed for 20 years at the Greenwich Observatory, but it is most certain, from his own showing, that "*turret clocks he did not understand, they were quite out of his line;*" * and that it was not till after the year 1843, that he had ever turned his attention to the construction of public clocks.

The foregoing fact sufficiently accounts for Mr. Dent having no tools; but he was not justified in the inference that there were no efficient tools in the clock trade.

It is also quite evident that Mr. Dent's first intention was to make the clock for the New Houses of Parliament on the same scale as that of the Royal Exchange, as is shown by his proposal, in this letter, to cast the works from the same models.

The bias of Mr. Airy's disposition in favour of Mr. Dent is displayed by this extravagant eulogium upon a clock, which was unfinished at the very time when he so praised it, and when there had been very little experience of its performance.

1845, Dec. 10. No. 12.

A. Milne, Esq., to Mr. *Dent.*

Sir, Office of Woods, &c., Dec. 10, 1845.

I AM, on behalf of the Commissioners of Her Majesty's Woods, &c., to acquaint you, in reply to your application of the 14th ultimo, that when the drawings and specifications for constructing the great clock at the New Houses of Parliament are completed, and can be submitted to the several clockmakers who may be applied to, as the basis upon which their tenders are to be founded, the Board will include you as one of the competitors to submit a tender for the same, as well as for supplying any other clocks that may be submitted to competition for the New Houses of Parliament.

I have, &c.,

(Signed) *A. Milne.*

1845, Dec. 14. No. 13.

Copy of a Letter from Mr. *E. J. Dent* to the *Commissioners of Woods*, &c.

My Lord and Gentlemen, 33, Cockspur-street, Dec. 14, 1845.

I MUST beg to offer a most respectful apology for troubling your Honourable Board with a short communication relative to the proposed clock for the Houses of Parliament.

Having learned that drawings are contemplated to serve as a model for the clock in question, I feel it due to my character, as an artist, to state respectfully, that if adherence to such model should be stringent on the maker, I must decline to come forward as a candidate.

With any suggestions from the Astronomer Royal, I should feel it to be a duty, and take a pride to comply; but I cannot engage to act under the directions of authority less eminent, or to follow instructions, which, by degrading me to the position of a mere executive mechanic, would prove detrimental to my reputation.

At the same time I beg to repeat to your Honourable Board, that a full and minute inspection of my great clock at the Royal Exchange will be afforded to any gentleman competent to form a judgment, and who is sanctioned by the authority of your Honourable Board.

I have, &c.,

(Signed) *E. J. Dent.*

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* See Appendix No. 1,—Letter from Mr. Whitehurst to Messrs. Parkinson and Frodsham.

Mr. Milne's intimation, in his letter of the 10th December, as to the course which the Office of Woods and Forests thought proper to pursue, seems to be the only reason for the disrespectful declamation which Mr. Dent here indulges in, and by which he seems to impugn the right of the Commissioners to exercise any judgment upon the course to be adopted in a matter which is wholly under their control. The subserviency which he exhibits towards Mr. Airy, whom he has proposed as sole referee, is so much in contrast with his want of deference to the Commissioners, that it affords confirmation (if any were wanting) of the reliance he felt on the support of Mr. Airy.

The constant endeavour of Mr. Dent to exhibit the Royal Exchange clock is fully accounted for by the recollection of Professor Airy's high, but questionable, encomium upon its superiority.

1846, June 11. No. 14.

C. Barry, Esq., to *A. Milne*, Esq.

Sir, Westminster, June 11, 1846.

In compliance with the request contained in your letter of yesterday's date, I send plans and section of the clock tower at the New Palace at Westminster, "showing the intended situation and the correct dimensions of the portion of the tower to be appropriated for the reception of the clock, with all its attached works and machinery."

I have, &c.,
(Signed) *Charles Barry.*

1846, June 20. No. 15.

Viscount *Canning* to *G. B. Airy*, Esq.

Sir, Office of Woods, &c., June 20, 1846.

I venture to trouble you by bringing the following question under your consideration, because it is one in which the public are much interested, and on which your advice will, in the opinion of all parties, be the safest and most satisfactory guide which the Commissioners of Woods and Forests can follow.

It is of importance that the clock which is to be placed in the clock tower of the new Houses of Parliament, should be the very best which the science and skill of the country can supply. The Commissioners of Woods are most anxious to ensure this, and they would, therefore, be glad to have the advantage of your opinion as to the best means of doing so. Whether it should be by calling upon some of the most eminent clockmakers to send in specifications, drawings, and estimates of the clock which each would recommend and would be prepared to make, furnishing them, of course, with all necessary information as to the position and architectural conditions of the clock, and eventually adopting that design, which, upon due examination by competent authorities, may be judged the best; or whether it would be better to place the matter in the hands of some one experienced mechanician skilled in such works, and to adopt the description of clock which he may recommend, leaving the execution of it open to tender, as is the case with all public works.

If you should be of opinion that the first course will be the best, I shall be greatly obliged to you if you will have the goodness to furnish me with the names of the persons whom you consider best qualified to design and construct such a clock as is required. If you should think that the design may with advantage be left to one person, I should be glad to know whom you would recommend for the service; and, in either case, whether there are any conditions as to principles of construction which it would be right to prescribe to the designers.

A plan, &c., of the clock tower accompanies this letter. Perhaps you will have the goodness to say whether it appears to you to convey such information as will enable those who may be called upon to design the clock to adapt their designs to the building.

I have, &c.,
(Signed) *Canning.*

Lord Canning, as the official head of an important department, takes a very proper view of the subject: he does not affect a knowledge which was not to be expected or required of him. He applies, with much consistency, to a gentleman holding a position of the highest scientific responsibility in a branch of knowledge which made it reasonable to expect that he would be the best guide whom the Commissioners of Woods and Forests could consult respecting the construction of the great clock for the New Palace. It is not the fault of the Commissioners if Mr. Airy should seem not to have justified the high opinion which it was fair to concede to his position as Astronomer Royal.

1846, June 22. No. 16.

G. B. Airy, Esq., to Viscount *Canning*.

Royal Observatory, Greenwich,
June 22, 1846.

My Lord,

I HAVE the honour to acknowledge the receipt of your Lordship's letter of the 20th instant, requesting my opinion as to the course which it would be desirable for the Commissioners of Woods and Works to follow in reference to the construction of a clock for the principal tower of the New Palace at Westminster, and enclosing plans and sections of the tower, and a letter of Mr. Barry's, numbered 4362, relating thereto. I return Mr. Barry's letter, retaining for the present the plans and sections (which, if agreeable to your Lordship, I should be glad to retain permanently), and I beg leave to reply to the general question as follows:—

A question of nearly similar import was addressed to me in 1843 by the Gresham Committee, in regard to the construction of a clock for the Royal Exchange. In reply I stated that (irrespectively of the choice of clockmaker) general conditions ought to be laid down as to the choice of materials, the circumstances affecting the durability of construction, the arrangement of bells and chimes, &c., and also that certain specific conditions applying to the accurate going of the clock, suggested by me (which conditions, with one modification, I shall state hereafter) should be laid down, and that intimation should be given to the clockmaker that his plans were to be submitted to me for my opinion before the work should be commenced, and that the Committee should, if they thought fit, refer to me for certificate or opinion at the termination of the work.

These conditions were adopted by the Committee, and the result is, that a clock has been mounted, which (as I fully believe) is superior even to most astronomical clocks in the steadiness of its rate, and which possesses these rare advantages: that the first stroke for each hour is correct as to time within less than one second, and that a person standing on the pavement can take time from the face without an error of one second.

I would, therefore, propose to the Commissioners of Woods and Works that a similar course should be followed in the instance of the clock for the New Palace at Westminster; and if the Commissioners shall think fit to desire my general superintendence in the manner which I have described, I will undertake that the clock which shall be mounted shall be creditable to the nation.

In regard to the selection of a maker, I suggested to the Gresham Committee the names of Mr. Vulliamy, of London (a maker of some celebrity, but said to be unmanageable in temper and very expensive in prices), and Mr. Whitehurst, of Derby (a man of reputation in the North of England, and known as the inventor of the watchman's clock). By arrangements, with which I am not acquainted, the work was placed in the hands of Mr. Dent, chronometer maker, of 82, Strand; and I am bound to say that Mr. Dent carried out my views most completely, making, in the mechanical arrangements which I suggested, some judicious alterations which received my entire approval.

Under all circumstances, considering that a new clock pretending to a degree of accuracy equal or superior to that of the Royal Exchange must, probably, contain some of Mr. Dent's inventions, and would at any rate be improved by his experience—that the trust is, so to speak, in some measure confidential, and that there is no such thing as a market for clocks of this size—I think that it would probably be the best course to transmit proposals (including my conditions) to Mr. Dent, and to ask for his tender. If his price should not be excessive, I would propose to employ him, without inquiry of other makers. If it appeared objectionable I would apply to others; but (I think) only to the two whom I have named.

I will now state three considerations to which I think it desirable to call the attention of the Commissioners:—

1. A pocket chronometer should be provided as a part of the clock establishment, and it should be the duty of the person who has charge of the clock to compare it with the signal ball or with one of the clocks at the Royal Observatory once every week; but I should hope that this may be considered as only a temporary arrangement; as there is great probability that a railway station for the South Eastern Railway will soon be made near Westminster Bridge, and that these railways will be prepared to receive telegraphic wires, it will then be a matter of little expense to arrange for the transmission of a signal to the Royal Observatory at every blow of the clock hammer. The severity of the check upon the going of the clock thus placed in the power of the Astronomer Royal would exceed anything that has ever been proposed.

2. It is probably the intention of the Commissioners that the clock should have chimes. These do not at all interfere with the rate of the clock; and they can be constructed by any good mechanic, Mr. Dent for instance, who has studied the machinery of chimes. But (judging from the history of the Royal Exchange clock) it seems likely that great annoyance may be produced by the mistuning of the bells; and this part of the work must be placed under the direction of some competent musical person.

3. As it is intended that this clock should be one of which the nation may be proud, and in which the maker ought to feel that his credit is deeply concerned, I would propose that the access to it should be made good, and even slightly ornamented, and that facility should be given to the inspection of the clock by mechanics and by foreigners.

I enclose, on a separate paper, a sketch of the conditions to which the maker of the clock ought to be subjected, for the properly carrying out my views. I need scarcely to observe that these conditions will not render it unnecessary to lay down others which may be suggested by the Commissioners or by their architect.

I have, &c.,

(Signed) *G. B. Airy.*

P.S.—I omitted to state that the plans and sections accompanying your Lordship's letter do, so far as I see, convey all the information which the clockmaker can require for the internal arrangements. He will, however, require information as to the nature of the clock face; for instance, as to whether it is to be formed in masonry or stucco, whether foliated, &c., or whether it is to be a plain metallic ring.

(Signed) *G. B. Airy.*

Mr. Airy's reply to Lord Canning is of a very different character from his Lordship's communication to that gentleman, and compels a course of less satisfactory observations.

His reference to the Royal Exchange clock (which most probably was made so immediately under his direction, that it may be considered to be almost his own work) would be perfectly free from objection, if that clock were really the perfect instrument which he has declared it to be; or if his treatment of all parties were less derogatory to himself and to them.

Instead of fairly complying with the request made to him by the Chief Commissioner, and advising "*whether application should be made to some of the most eminent clockmakers, or whether it would be better to place the matter in the hands of some experienced mechanician,*" Mr. Airy is not content simply to name Mr. Dent as such mechanician; for although he cites the names of two persons, whose reputation, as experienced and practical clockmakers, he could not impeach, one of these persons he disposes of by making a most gross personal, and even libellous, attack upon his private character;* and passes abruptly over the other party, as if his reputation in the North of England were unworthy to be mentioned in the South, and as if his invention of the Watchman's Clock were a thing too trivial to be noticed. Then contrast, with his great injustice to Mr. Vulliamy and Mr. Whitehurst, the warm and flattering commendations which he bestows on Mr. Dent, and take into consideration the earnest pledge of support which he gave to Mr. Dent just twelve months previously; and surely it must be admitted that Mr. Airy, although a very zealous friend, cannot, in this transaction, be regarded as a fit and impartial referee.

1846, July 6. No. 17.

C. Barry, Esq., to Mr. *Vulliamy*.

Dear Sir, Westminster, July 6, 1846.

I AM requested by Her Majesty's Commissioners of Woods, &c., to inform you that they have determined to invite the tender of plans and specifications from different quarters for the great clock for the Palace at Westminster; such plans and specifications to be based upon the enclosed general conditions prescribed by the Astronomer Royal, who has recommended that application should be made to Mr. Dent, of London, and Mr. Whitehurst, of Derby, as well as to yourself.

I am also requested to inform you, that if in the course of the researches and inquiries which in April, 1844, you were authorised to make, and for which the sum of 100 guineas was in any case to be allowed to you for plans and specifications of the clock in question, you should have acquired any information which may lead you to suggest a departure from the enclosed conditions, you will be at liberty to do so in sending in your plans.

And I have further to signify to you, that the Board consider it may be convenient that, together with your plans and specifications for the proposed clock, you should also submit the estimated cost of supplying and completing the same in all respects according to the conditions, putting up, and keeping for a given time.

I have, &c.,

(Signed) *Charles Barry.*

CONDITIONS to be observed in regard to the CONSTRUCTION of the CLOCK of the NEW PALACE of WESTMINSTER.

I.—*Relating to the Workmanlike Construction of the Clock.*

1. The clock-frame is to be of cast iron, and of ample strength. Its parts are to be firmly bolted together. Where there are broad bearing surfaces, these surfaces are to be planed.
2. The wheels are to be of hard bell-metal, with steel spindles working in bell-metal bearings, and proper holes for oiling the bearings. The teeth of the wheels are to be cut to form on the epi-cycloidal principle.
3. The wheels are to be so arranged that any one can be taken out without disturbing the others.
4. The pendulum pallets are to be jewelled.

II.—*Relating to the accurate going of the Clock.*

5. The escapement is to be dead-beat, or something equally accurate, the recoil escapement being expressly excluded.
6. The pendulum is to be compensated.
7. The train of wheels is to have a remontoir action, so constructed as not to interfere with the dead-beat principle of the escapement.
8. The clock is to have a going fusee.

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* See Appendix No. 2.

9. It will be considered an advantage if the external minute-hand has a discernible motion at certain definite seconds of time.

10. A spring apparatus is to be attached for accelerating the pendulum at pleasure during a few vibrations.

11. The striking machinery is to be so arranged that the first blow for each hour shall be accurate to a second of time.

III.—*Relating to the possible Galvanic Connexion with Greenwich.*

12. The striking detent is to have such parts that, whenever need shall arise, one of the two following plans may be adopted (as, after consultation with Mr. Wheatstone, or other competent authorities, shall be judged best;) either that the warning movement may make contact, and the striking movement break contact, for a battery, or that the striking movement may produce a magneto-electric current.

13. Apparatus shall be provided which will enable the attendant to shift the connexion, by means of the clock action, successively to different wires for different hours, in case it should hereafter be thought desirable to convey the indications of the clock to several different places.

IV.—*General Reference to the Astronomer Royal.*

14. The plans, before commencing the work, and the work when completed, are to be subjected to the approval of the Astronomer Royal.

15. In regard to the Articles 5 to 11, the maker is recommended to study the construction of the Royal Exchange clock.

June 22, 1846. (Signed) *G. B. Airy.*

1846, July 22. No. 18.

Mr. *Vulliamy* to *Charles Barry*, Esq.

Dear Sir, Pall Mall, July 22, 1846.

I BEG to acknowledge the receipt of your letter of the 6th instant, and its enclosure, containing a copy of the "Conditions to be observed in regard to the construction of the clock for the New Palace at Westminster."

In reply, I beg to say, that my general rule of conduct has been in all cases to decline competition: and though it deserved consideration whether an occasion like the present should form an exception, I have concluded to decline it, but with much reluctance, and after having consulted such of my friends as I considered best qualified to give a correct opinion on the subject, and who agree with me on the following grounds:—

Had the Office of Woods proposed referring the matter to several individuals conjointly with the Astronomer Royal, such as the Rev. Robert Willis, of Cambridge, the President of the Royal Astronomical Society, the President of the Society of Civil Engineers, and others whom I could mention, I should, so far from objecting, have been pleased that such a course had been pursued. Professor Willis is probably the individual best qualified to give a correct opinion on such a subject in Europe, certainly in this country, as he has abundantly shown by his numerous works upon mechanical subjects.

Captain Smyth, the President of the Astronomical Society, has been referred to in a similar manner by Her Majesty's Government on similar occasions, and the fitness of Sir John Rennie for such a reference is too well known and acknowledged to render any explanation on my part necessary. I object to the Astronomer Royal as sole referee, for the following reasons. First, because I consider there are other individuals certainly as well, if not better, qualified to offer an opinion on the subject; and secondly, because he has shown himself to be strongly prejudiced in favour of an individual known for many years as an eminent maker of marine chronometers, but who has only within the last three years turned his attention to making public clocks.

In a Report from the Astronomer Royal to the Gresham Committee, dated the 27th October, 1844 (see printed Report of the Committee, dated 23rd January, 1845), speaking of Mr. Dent's clock at the Royal Exchange, he thus expresses himself: "*I have no doubt that it is the best public clock in the world.*" It further appears by the Report that at the time it was made, the clock was not quite completed, and, strange to say, at the present time the chimes are not finished, although, according to the original contract, dated 27th July, 1843 (see page 205 of the same Report), this clock and its chimes were to have been fixed and completed by the 31st of May, 1844. How far this opinion of the Astronomer Royal is correct I have no means of judging, but in the opinion of my friends it fully justifies the conclusion I am come to. I think it quite beneath me to be influenced by any personal motives as regards Mr. Dent for refusing to enter into the competition, or I should make some remarks upon his utter disregard to truth, as shown in a letter he addressed to Mr. Whitehurst, of Derby, which has since been printed, in which, to answer his own purpose, he introduces my name; but, in justice to Mr. Whitehurst, I am bound to say, that Mr. Dent's conduct towards him on the occasion of the competition for the clock for the Royal Exchange was disgraceful in the extreme.*

I have not yet seen Mr. Dent's clock at the Royal Exchange, but Mr. R. Lambert Jones, the chairman of the Gresham Committee, has promised to take me to see it as soon as the whole is completed.

I have to apologise for having occupied so much of your time, but I thought it due to the Office of Woods, to which, as a public Board, I consider myself under many obligations, and to you, to state fully and unreservedly the motives that have induced me to decline the competition.

I have, &c.,

(Signed) *B. L. Vulliamy.*

See Appendix No. 1.

1846, August 31. No. 19.

C. Barry, Esq., to *A. Milne*, Esq.

Sir, Westminster, August 31, 1846.

I FORWARD to you herewith the drawings and specification for a clock for the New Palace at Westminster, prepared by Mr. Vulliamy in accordance with the agreement which he entered into with the Board some time since, together with a paper containing some remarks which he has made upon the specification of the Astronomer Royal for a clock for the same building, which he has begged of me to forward to you at the same time. I send also a letter which Mr. Vulliamy has addressed to me on the subject.

I have, &c.

(Signed) *Charles Barry.*

My dear Sir, Pall Mall, August 29, 1846.

I AM at last enabled to send you the two portions of the description of the clock for the New Palace at Westminster, together with 18 additional drawings, making a total of 36 drawings.

I have it in contemplation to make a few more drawings, particularly in reference to that part of the clock which carries the hands, but my doing so must depend on the state of my health, which, from hard work, and sitting up very late, drawing and writing, renders it necessary I should absent myself from business for a short time.

I have not prepared any estimate of the probable expense of this clock. To furnish an estimate did not form any part of my agreement, and a tolerably correct one would be a work of great labour, and attended with considerable expense; moreover, since I have declined to make the clock under the immediate and sole direction of the Astronomer Royal, my estimate would be useless.

No care or attention has been wanting on my part in arranging, as I conceive to the best advantage, the different parts of this immense clock. I went to Paris expressly to see the public clocks exhibited at the last Exposition de l'Industrie Française, and made notes of what I saw; the first part of the description of the clock, which is by far the most important: the second, relating entirely to details and its 18 drawings, were submitted by me, to Captain Smyth, R. N., P.R.A.S. and the Rev. Robert Willis, of Cambridge, who expressed themselves much pleased, as well with my general arrangements as the detail. From these gentlemen I received some very valuable suggestions, and in consequence made several alterations in my original plan. They both authorised me to say they should be very happy to answer any inquiries that might be made of them in reference to my plan for this clock.

The drawings are perfectly plain, being plans, elevations, and sections drawn full size, and to different scales, with no more colour than was absolutely necessary to render them perfectly intelligible. I have carefully avoided all attempts at furnishing showy drawings or representations of the clock in perspective, which only tend to mislead; and I am persuaded you will say that I have acted perfectly right in so doing.

I have always made it a rule not to be too hasty in coming to a conclusion, and accordingly I have very carefully again examined the specification furnished by the Astronomer Royal. The result has been to confirm my former determination. I send you a copy of some remarks which the second examination of that paper led me to make upon its contents. As all my communications with the Office of Woods respecting this clock have been through you, I shall be much obliged if you will forward this with the other papers to the office.

I have nearly attained the allotted age of man, "threescore years and ten," and have devoted the 30 best years of my life to the improvement of public clocks, and I may add, with some success, for most of the modern improvements in these clocks have originated with me. My fathers and I have been in the service of the Sovereigns of these realms upwards of a century; my great-grandfather was clockmaker to George II.; and I certainly should have much liked to have finished my professional career by making this clock. I therefore regret that circumstances have occurred which I fear will prevent it.

In conclusion, I beg to assure you, that I shall never forget the very honourable and friendly manner in which I have uniformly been treated by you throughout this business.

I am, &c.,

C. Barry, Esq. (Signed) *B. L. Vulliamy.*

CLOCK proposed for the NEW PALACE at WESTMINSTER, A.D. 1846.

AN account of an Eight-day Clock, proposed to be erected at the New Palace, Westminster, to show time upon four faces, about 25 feet in diameter, and to strike the hours upon a bell of 14 tons, and the quarters upon eight bells, with calculations of the size, weight, strength, &c., of the different parts necessary for accomplishing the said intention; with a description of what is considered to be the best mode of fixing the same.

By *B. L. Vulliamy*, Clockmaker to the Queen, &c.

This is a very condensed abbreviation of the specification which was sent to the Commissioners of Woods and Forests. It was accompanied by 36 drawings. The technical details of the specification have been incorrectly printed in the Parliamentary Papers. The reason for giving this abridgment is, that the original and more lengthy document would not be intelligible without the drawings.

The clock is divided into three distinct parts; and, with the exception of the communication by which the quarters are discharged by the going part, there does not exist any connexion between the going part and either of the other parts of the clock. The hours are discharged by the quarter part.

The going part is in itself extremely simple, and consists of only three wheels and two pinions: these give

motion to nine other wheels, of which seven are the bevel wheels, employed to effect a communication from the clock to the four pairs of hands. The clock is kept going while being wound. The diameter of the great wheel is 24 inches; it is cut into 180 teeth, and makes one revolution in five hours. The centre wheel is 21 inches in diameter, and has 300 teeth. The centre wheel-pinion has 36 teeth, and the scape-wheel pinion 20 teeth. The barrel, round which the rope which carries the weight is coiled, is 14 inches in diameter, and makes 36 revolutions, or turns, in 8 days and 7 nights. The work for communicating the motion from the body of the clock to the four pairs of hands is entirely carried by the frame of the going part, and is in no way connected with the building. The external hands may be set to time, when necessary, with the greatest facility, by means of the perfect accordance between these hands and those which indicate the time upon an internal dial, the seconds being shown by a hand which advances one division upon a graduated circle every two seconds of time.

The striking parts are calculated to meet Mr. Barry's instructions, viz., to strike the hours upon a bell of from 8 to 10 tons (which was afterwards increased to 14 tons), and the quarters upon 8 bells: the requisite strength of this portion of the work has, in consequence, been carefully provided for.

The hour train consists of three wheels and three pinions. The hammer is raised by the second wheel. The great wheel is 3 feet in diameter, and is cut into 150 teeth; the second wheel is 2 feet 10 inches in diameter, and has 256 teeth; and the third wheel has 96 teeth. The second wheel-pinion has 50 teeth, and makes three revolutions to one of the great wheel; the third wheel-pinion has 30 teeth, and the fly-pinion 24. Independently of the above wheels and pinions, which constitute the train, there is the locking wheel and pinion: this wheel is 28 inches in diameter, and has 234 teeth, and the pinion 24. The barrel is 2 feet 6 inches in diameter, 3 feet 8 inches long, and is intended to make nearly 49 revolutions, so as to enable the clock to strike during 8 days and 7 nights with once winding.

The quarter train consists of the same number of wheels and pinions. The great wheel is larger than that in the hour train, being 3 feet 7½ inches in diameter, and is cut into 180 teeth; the second wheel makes one revolution in one hour, is 2 feet 10¾ inches in diameter, and has 260 teeth; the third wheel has 144 teeth. The second wheel-pinion has 60 teeth, and makes 3 revolutions to one of the great wheel. The locking wheel is a blank wheel, which carries five pins, four to lock the quarters, and one to discharge the hours. To the second wheel is attached the barrel carrying the pins that raise the quarter hammers, which, consequently, makes one revolution in an hour. It is arranged to strike four quarters previously to the hour, and the other quarters at the proper times, each upon 8 bells. The barrel carrying the line is 2 feet 3 inches in diameter, and 4 feet 2 inches long; it will make 60 revolutions, and enable the clock to strike 8 days and 7 nights with once winding.

It is proposed to make the wheels and large pinions of gun metal; but the smaller pinions are to be of steel. The pivots are to work in gun-metal holes, the larger in that description of hole called a plummer block. All the arbours are to be made of steel, with the exception of the striking-barrel arbours, the ends only of which it is proposed should be steel: all the smaller pivots to be furnished with cocks, to carry screws to regulate the end-shake. The barrels, or drums, to be made of well-rolled copper.

The beds or bases which carry the wheels and different parts of the work are to be of cast iron, and all the screws and fastenings of gun metal, in order to avoid the effects of rust.

This mode of arranging the work in large clocks possesses many advantages over the ordinary construction, some of which will be noticed. In the latter, the whole of the work is contained in one frame, which being of necessity composed of several pieces, bolted and screwed together, it follows that, whenever it is necessary, for the purpose of cleaning or otherwise, to remove one of the bars of the frame, two or more of the wheels, or other pieces, pivoted into the same bar, become loose, and disengaged at the same time. This is always attended with much inconvenience and risk of damaging the work, particularly the teeth of the wheels. In the new construction, the going or striking part or parts are perfectly detached from each other: each part is supported upon a separate bed of cast iron, and the arrangement is such that any of the wheels, or principal pieces, can be removed without disturbing any of the others. The pendulum bob is much heavier than those which are applied to turret clocks of the common construction, and, consequently, will be less affected by external causes. A 2″ pendulum, accompanied by a seconds-hand, affords great facility for regulating, and keeping a register of, the going of the clock. The suspension of the pendulum is perfectly independent of the clock, and the clock can be cleaned without disturbing the pendulum. There are a variety of adjustments connected with the pendulum and escapement for which this construction offers considerable facilities. The escapement is that which is commonly known as Le Pante's dead escapement, and it is, in many respects preferable for a large clock to that of Graham. All clocks showing the time externally are liable to be stopped by snow-storms impeding the hands; and whenever they are brought to rest in this manner, the point of the pallet is liable to come in contact with the point of the tooth of the wheel, or to catch, as it is termed. This is an accident of frequent occurrence; and when it happens to Graham's escapement, in which, the wheel being made of softer metal than the pallet, which is of steel, the former is very liable to be damaged from the pressure caused by the weight of the bob, and, in that case, the only remedy is a new wheel; whereas, in Le Pante's escapement, the damaged pin can be taken out and replaced by a new one, and the wheel will be restored to as perfect a state as before the accident. The mode of communicating the motion from the clock to the hands is extremely simple, and perfectly independent of the building: it is entirely supported by, and attached to, the base of the going part. Lastly, this construction offers very great facilities for cleaning, applying oil to the works, and keeping them in general good order.

SOME REMARKS upon a SPECIFICATION furnished by the ASTRONOMER ROYAL for a Clock for the New Palace at Westminster, entitled "Conditions to be observed in regard to the constructing the Clock for the New Palace, Westminster."

Remarks.	*Copy of the Specification.*
I have constantly made the frames of my great clocks of cast iron; but in many instances upon a new and much improved construction,	1. The clock frame to be of cast iron, and of ample strength. Its parts are to

Remarks.

with the bearing surfaces made to fit correctly; and when expense was not an object, I have employed gun metal in preference to iron screws to put them together.

I have not seen any wheels made of bell metal, or ever heard of any being so made. I am apprehensive that the hardness and brittleness of the metal would offer considerable difficulties to its being employed for that purpose. How far bell metal would answer for pivot holes is also very doubtful, and can only be satisfactorily determined by experiment. I was, I believe, the first clockmaker who ever employed gun metal for the wheels and pinions, and pivot holes of great clocks. This I did so long ago as the year 1829, at the suggestion of the late Sir John Jones, then Commanding Royal Engineer at Woolwich. Since that time I have constantly employed gun metal, and with the greatest success. The small pinions I make of steel. Within the last few years my example has been followed by several clockmakers. It is a matter of course that the wheels should be cut upon the epi-cycloidal principle.

This is a most convenient arrangement, and one which I first put in practice so long ago as the year 1827, since which period I have repeatedly adopted it.

To this I object for several reasons, but principally because the advantages resulting from jewelling the pallets can be obtained in a preferable manner.

I never applied to a public clock any but a dead escapement; this I have made upon both Graham's and Lepante's construction.

To compensate a two-seconds pendulum is always attended with much inconvenience. The pendulum of the great clock at the Hotel de Ville at Paris, made by Lepante, is a two-seconds pendulum, with a nine-bar gridiron rod; in this case the great weight of the rod is a serious objection. If the pendulum is suspended, as I have proposed in my specification, a compensation ceases to be necessary.

I decidedly object to employing a remontoir; it is an adjunct which has long ceased to be employed in the case of marine chronometers, and is equally objectionable for clocks. The most eminent chronometer makers of the present day are of this opinion.

A weight clock cannot have a fusee; but so long ago as the year 1815 I applied a going barrel to a turret clock, which I suppose is what is here meant, though I entertain some doubt whether the old method, commonly known by the appellation of the bolt and shutter, is not preferable.

I have always considered it to be very desirable that the advance of the hands of a large clock should be as uniform as possible; and I apprehend that any sudden advance or jerk of the minute hand, which in the case of this clock will be a lever of about 12 feet long, would be attended with much practical inconvenience.

I am not aware of the utility of this contrivance applied to a pendulum supported as I should support this one were I to make the clock.

The clock may be made to discharge the striking at any second of the 3,600 forming the hour, that may be most convenient; but that the clock should invariably strike a similar blow, whether of the quarters or hours, at the same second of time will, I fear, be difficult to accomplish; neither do I perceive the practical utility of its so doing. Sound, in a calm, travels at the rate of 1,142 feet in a second of time; there are 5,280 feet in a mile, consequently, at that very short distance, between four and five seconds would elapse before the striking could be heard; and at a distance of five miles the interval would be 25 seconds; and at a distance of 10 miles, 50 seconds. As the wind materially influences the rate at which sound travels, and as an individual to leeward of the clock will, when the wind blows, hear it sooner than one at the same distance to windward, the period at which the striking will be heard depends, in addition to the distance from the clock, also upon the situation of the hearer in reference to the direction of the wind. For these reasons it appears to me that the advantage to be gained from striking the first blow "for each hour to a second of time," is more imaginary than real, and of no practical utility; besides, the means employed to attain this end may be attended with some serious inconvenience

Copy of the Specification.

be firmly bolted together. Where there are broad bearing surfaces, those surfaces are to be planed.

2. The wheels are to be of hard bell metal with steel spindles, working in bell metal bearings, and proper holes for oiling the bearings. The teeth of the wheels are to be cut to form an epi-cycloidal principle.

3. The wheels are to be so arranged that any one can be taken out without disturbing the others.

4. The pendulum pallets are to be jewelled.

5. The escapement to be dead, or something equally accurate; the recoil escapement being expressly excluded.

6. The pendulum to be compensated.

7. The train of wheels to have a remontoir action, so constructed as not to interfere with the dead-beat principle of the escapement.

8. The clock to have a going fusee.

9. It will be considered an advantage if the external minute hand has a discernible motion at certain definite seconds of time.

10. A spring apparatus to be attached for accelerating the pendulum at pleasure during a few vibrations.

11. The striking machinery is to be so arranged that the first blow for each hour shall be accurate to a second of time.

Remarks.

in the construction of the clock. The case is very different with the fall of the ball at Greenwich, from which this idea was probably taken. The observation there is one of sight; and the ball is seen to fall the same instant, whatever may be the distance of the spectator.

I confess I possess but little information on the subject referred to in Nos. 12 and 13 in the Astronomer Royal's specification. My plan for the clock was matured long before I received the copy of that specification; and the succeeding Article, No. 14, having compelled me to relinquish my claim to be employed to make the clock, I have thought it unnecessary to apply for any further information. I will therefore content myself with observing, that the arrangements I have proposed for the striking are extremely simple, and I have no doubt might be made to answer the required purpose.

I should have great pleasure in submitting the plan I have made for this clock to the Astronomer Royal, as I did to Captain Smyth, R.N., President, R. A. S., and to the Rev. Robert Willis, of Cambridge. From both these gentlemen I received much valuable advice and assistance, for which I shall always feel much obliged. But I object entirely to comply with this condition. All the information the Astronomer Royal can possess on the subject must be theoretical. It is probable that he has only turned his attention to the subject since 1843, when he wrote the specification for the clock at the Royal Exchange. There are some papers on the subject of horology written by him in the Transactions of the Cambridge Philosophical Society, but I am not aware that mention is made of public clocks in any of these papers. To be enabled to form a correct estimate of the merits and demerits of a machine of this nature and magnitude, and how far it is calculated to answer the purpose for which it is intended, experience is as necessary as correct theory.

There are very few things from which some information may not be acquired, and I hope in due time to examine the clock at the Royal Exchange. I have not yet seen it; neither should I, for obvious reasons, have chosen to see it, until I had forwarded to Mr. Barry, the architect, the plan for a clock, which Her Majesty's Commissioners directed me to prepare for the New Palace at Westminster.

(Signed) B. L. Vulliamy.

August 29, 1846.

Copy of the Specification.

12. The striking detent is to have such parts, that whenever need shall arise, one of the two following plans may be adopted (as after consultation with Mr. Wheatstone, or other competent authorities, shall be judged best), either that the warning movement may make contact, and the striking movement break contact, for a battery, or that the striking movement may produce a magneto-electric current.

13. An apparatus shall be provided that will enable the attendant to shift the connexion, by means of the clock action, successively to different wires for different hours, in case it should hereafter be thought desirable to convey the indications of the clock to several different places.

14. The plans, before commencing the work, and the work when completed, are to be subjected to the approval of the Astronomer Royal.

15. In regard to the Articles 5 to 11, the maker is recommended to study the construction of the Royal Exchange clock.

A Return of all Specifications and Estimates sent by Mr. *Dent* and by Mr. *Whitehurst* to the Office of Woods, &c., relating to the Great Clock.

Mr. Dent's Tender.

1846, Aug. 8. No. 20.

Mr. *Dent* to the *Commissioners of Woods and Forests.*

My Lord and Gentlemen, 33, Cockspur-street, August 8, 1846.

I hereby agree to complete and erect in the tower, and keep in order for the first 12 months, the clock for the New Houses of Parliament, agreeably to the plans and specifications, and to attend, without additional charge, to any directions of the Astronomer Royal, for the sum of 1500*l.*

I beg further most respectfully to state, that no just conclusion can be arrived at of the real value of such an elaborate piece of machinery as the clock, until it be fixed and going in the tower; I therefore agree not to receive payment until I obtain the certificate of the Astronomer Royal; and if, in the event of his inspecting the accounts, he should be of opinion that the sum stated should be reduced, I will agree to his decision.

(Signed) *Ed. J. Dent.*

Note.—This estimate is superseded by the amended estimate (inserted in the previous Return), including the sum of 100*l.* for the electro-magnetic apparatus subsequently proposed by the Astronomer Royal, making the total amount of Mr. Dent's tender 1600*l.*

Remarks for Consideration in Constructing the Clock for the New Houses of Parliament.

By *E. J. Dent.*

1. In arranging the mechanism necessary to enable four sets of hands to traverse dial plates of such gigantic dimensions as 22 feet in diameter, two subjects especially require attention; one the movement of the hands, and the other the impulse to be given to the pendulum.

1st. The weight of the four sets of hands, with the counterpoises, together with the eight motion wheels and the seven bevel wheels of 20 inches diameter, will amount to about 12 hundred-weight. The power necessary to overcome the inertia and friction must therefore be considerable.

2ndly. The weight necessary to make the pendulum vibrate a semi-arc of two degrees is 12 ounces on a radius of 4½ inches.

To attempt the accomplishment of these ends with the same maintaining power as is usually done in the ordinary large clock appears injudicious, particularly as nearly the whole force of the weight is given to the pendulum before such a mass as 12 hundred-weight can be set in motion. Accordingly, we see that in the majority of turret clocks the whole train of wheelwork and the escapement are not only made both large and heavy, but with pivots large in diameter, a construction incompatible with good and lengthened performance. It is true that the introduction of a remontoire does much to correct this defect; still the remontoire weight is raised with great force, on account of its small resistance and nearness to the maintaining power as compared with the motion of the hands driven by rods aud through many bevel wheels. To obviate these defects as much as possible, perhaps the best method would be to place an auxiliary weight with a perpetual barrel, as seen in drawing No. 6, at *e*, to drive the whole of the motion work. This weight could easily be varied so as just to overcome the resistance of the hands, and even adjusted in such a manner as slightly to press forward the going train. Under this condition, the circumstance of the going train moving forward with greater speed than the auxiliary train of wheels would give a small impulse to start it from its dead point. Again, if it were found that from the great weight of the hands, &c., being put in motion there should be recoil in the minute hand, a wheel driving a fly could be introduced, which would admit of the hand being governed to any velocity required. If the fly were introduced into the auxiliary train, the clock would be made to discharge it by means of a simple arrangement similar to the remontoire, and this would effectually obviate all irregularities arising from the effects of gusts of wind on the hands. The great advantages of introducing an auxiliary train would be, that the going train could be made light, and the escapement more delicate, and the pivots much smaller in diameter, all which are desiderata essential, not only to the durability of the work, but to the lengthened continuance of good performance.

2. A fly is introduced into the drawing of the proposed clock, to check the sudden blow given by the long tooth of the remontoire wheel on the cylinder (as seen in drawing No. 4, at *b*). In the Royal Exchange clock the remontoire is checked by a spring, which increases in its tension proportionably to the momentum of the remontoire wheel. Perhaps, however, the introduction of the wheel and fly is the most sure and effective method.

3. *Regulation.*—The rough adjustments to approach mean time, to be made by the screw *d*, in drawing No. 3. The finer adjustments to be effected by a series of weights, varying from half an ounce to eight ounces; these weights to be placed on the top of the pendulum bob, at *e*. The setting of the clock to a fraction of a second to be made, as Mr. Airy suggested for the clock of the Royal Exchange, and seen and described in the specification.

4. *Striking Work.*—The striking principle of the locking plate is, for its firmness and security, adopted in preference to the rack and snail, the latter of which depends on flirts, and the gathering up of the rack by a pallet. It is intended to raise the hammer to strike the large bell and quarters from the first power, as there is sufficient fall for the weights, as shown in drawing No. 1.; there being no intermediate pinion and wheel between the hammer raised and the weights. The Exchange clock, from want of depth for the fall of weights, was compelled to have a wheel and pinion, as seen in drawing No. 5.

5. *Hands.*—In the specification the hands are supposed to be of copper. Perhaps it is worth a consideration whether they would not be lighter and stronger if they were made of iron galvanized.

6. *Supports for Clock.*—The clock in No. 1 is represented as standing on cast-iron brackets, which are introduced to give effect to the drawing. The clock is to stand on stone corbels, as shown in drawing No. 2, at *b*.

7. *Clock Room.*—The clock should be placed in a light room, as low down in the tower as possible, and should be exhibited to public view. The introduction of the auxiliary force to drive the hands is perhaps favourable to such an arrangement, by equalizing the effect of tension in the rods, &c. When clocks are placed high up in the towers it is with great labour that they are kept free from rust, arising principally from condensation.

8. In adapting the auxiliary train, it may be of importance to consider whether or not a series of clocks at a distance could not be made to detent on the large clock, and if so, two desirable objects would be obtained; 1st, uniform time; 2ndly, a great saving in expense; and in addition the architect could, perhaps, arrange a better style of dial than is generally effected by the introduction of a clock-case.

9. *The Bells.*—As the bells may be considered as part of the clock, perhaps it would be advisable that the order should be given by the clockmaker. The clockmaker will then alone be responsible for the whole.

Abstract of Remarks respectfully submitted for the advice of the Astronomer Royal.

1. Driving of hands by an auxiliary weight.
2. Whether a fly is better than a spring to check the momentum of train.
3. On means of regulation to approach mean time.
4. Striking work.
5. On the metal for the hands.
6. Supports for clock.
7. Clock room.
8. If the large clock may govern others at a distance.
9. The ordering of the bells by the clockmaker.

(Signed) *Ed. J. Dent.*

SPECIFICATION for a large CLOCK for the NEW HOUSES of PARLIAMENT, by *Ed. J. Dent*, Clockmaker to the Queen.

I.—*Relating to the workmanlike Construction of the Clock.*

1. The clock to go eight days, to strike the hours, and two blows at every quarter. The clock frame to be of cast iron, having the broad bearing surfaces planed, and bolted together, as shown in the drawings Nos. 1 and 2.

2. The whole of the wheels to be of gun metal, with the exception of the escapement wheel, which is to be of the best brass, well hammered, and the wheel to be gilt to preserve the oil. The spindles to be of steel, hardened and tempered, and working in gun metal bearings, with caps to preserve the oil, into which is inserted a steel screw, with its end hardened, to adjust the endshakes and reduce the friction, as seen in drawings Nos. 1 and 2, at *a*. The form of the wheel teeth of the driver to be epi-cycloidal and the driver hypo-cycloidal, and the thickness of the teeth to be so constructed as to commence driving at the line of centres.

3. The wheels to admit of being taken out of the frame singly without disturbing the others. Plan and description of work to drive the four sets of hands.

A cast-iron girder, to extend the whole length of clock room, as shown in drawing No. 6, at *b*, and to be built into the wall of the tower. The underneath surface to be planed to receive the frame C, which carries the bevel wheels for the four dials. Each dial work to have two uprights of cast iron, as seen at *d*, with a cross-piece to carry the motion wheels and axes for hands; cast-iron louises to be let into the wall to receive the bolts. The stability of the dial work being most important, no wood work will be used in any part. The eight expansion joints to be made of gun metal. The bevel wheels to be of gun metal, 20 inches in diameter. The full size and form of tooth, as well as the pitch of tooth, is shown in the drawing No. 7.

Hands.—The hands to be of copper, and to have a strong brass rib at back, to be a continuation of the socket of hour and minute hands; the hands to be strongly gilt, as well as the hours and minutes, on stone dial plate. The whole of the bevel wheels, and the work of the four sets of hands, to be driven by an auxiliary weight, as seen at *e*, No. 6. The barrel to be so constructed that the hands will keep going whilst winding up the auxiliary weight.

Pulley work.—Cast-iron girders to be let into the walls to receive the pulleys and lines. The pulleys to be in iron frames. The axes of pulleys to be pivoted, and to run in gun-metal bearings. The lines to be of patent wire rope. The weights to be of cast iron.

4. The pallets of the escapement are to be jewelled with sapphires, and not with agate, or any soft stone, as is usual.

II.—*Relating to the accurate going of the Clock.*

5. The escapement to be dead-beat.

6. The pendulum to be two seconds, with a zinc column for the compensation, similar to the one in the clock of the Royal Exchange. The bob to be a turned cylinder of gun metal, filled with lead, and to weigh about three cwt., as seen in drawing No. 3, at *a*. The pendulum to be suspended from a cast-iron plate, firmly bolted into the tower, as seen in drawing No. 1, at *b*.

7. *Remontoire.*—The remontoire to be discharged every 20 seconds, and to be let off by means of a cylinder revolving round once in a minute, having three notches cut half-way through at angles of 120 degrees each, allowing the long teeth to pass, as seen in drawing No. 4, at *a*. The whole of the escapement to be covered with plate glass, fitted into a metal frame, and nearly air-tight, as seen in drawing No. 1, at *c*.

8. The clock to have a going barrel, similar in construction to that invented by Mr. Airy for the great Northumberland telescope at Cambridge, and first introduced into the clock of the Royal Exchange, as seen at *d* in drawing No. 1.

9. The minute hand to be discharged every 20 seconds, when the end will move over 3·84 inches each time. All the hands to be counterpoised, by each having two balls at an angle of 120° from the hand.

10. To have a spring apparatus to accelerate the pendulum, as shown in drawing No. 3, at *b*. To be moved in clock room, as seen at C.

11. The drawing No. 5 shows the position of the hammer tail after warning at *a*, and is ready to fall instantly; seen also in drawing 1 by the dotted line at ..... *e*.

III.—*Relating to the possible Galvanic Action with Greenwich.*

12. A metal wheel, having the spaces filled with ivory, so as to make and break contact every 20 seconds, as seen in tracing No. 6, at *a*.

13. The connexion to be made and broken at pleasure. The application cannot in any way interfere with the going of the clock, whether kept on or off.

IV.—*General Reference to the Astronomer Royal.*

14. The instructions of the Astronomer Royal to be followed, and the work, when completed, to be subjected to his approval.

15. In the accompanying plans for the proposed clock, the principle of the construction of the Royal Exchange clock has been studied.

33, Cockspur-street.

On Mr. Dent's offer to make the clock according to his specification for 1500*l.*, it may be observed, that he, virtually, acknowledges that he is unable to estimate the value of the work which he undertakes to execute. Consequently, it may be inferred, that he knowingly, and professedly, undertakes to make this expensive clock at a positive loss.

The continual reference to Mr. Airy induces the question, how far Mr. Airy is qualified to give an opinion on the value of such a clock as is required on the present occasion? It is generally understood that Mr. Airy's experience has been limited to works of a delicate nature, and has not extended to clocks of the dimensions now proposed. The proper parties to estimate the value of such a clock as is contemplated in Mr. Vulliamy's specification, are persons of the highest reputation in this country as manufacturers of large engines and other machinery.

For some reason, which does not very clearly appear, Mr. Dent precedes his specification by "*Remarks for consideration.*"

The first, as to the weight of the hands and bevel wheels, is hypothetical, and to be intelligible, should have been accompanied by some data, for it is not evident how the machinery, mentioned by Mr. Dent, can amount to so much as 12 cwt.

The second is unintelligible.

To overcome the difficulties to which he adverts, Mr. Dent proposes to employ "*an auxiliary weight, with a perpetual barrel;*" but he does not show how this weight is to be wound up, or what is meant by "*a perpetual barrel.*"*

The mode of supporting the clock, described in the sixth remark, appears to be the same as that of the clock at the Royal Exchange.

The proposal to place the clock as low as possible in the tower, merely to be the better exhibited to public view, is objectionable on many accounts. The great distance at which the dials would be placed above the clock, would necessitate the use of a very complicated communication, which it is at all times desirable to avoid; first, on account of the effect produced by change of temperature; secondly, because of the great additional weight, and consequent increase of friction, and the necessity which would thence arise of an increase of the maintaining power.

The fallacy of Mr. Dent's proposal, in the eighth remark, to make "*a series of clocks at a distance detent on the large clock,*" is pointed out in the observations upon Mr. Airy's letter, of the 11th February, 1847, wherein a similar scheme is propounded.

On the ninth remark, it may be observed, that the clockmaker can have no interest in ordering the bells, unless it be in a pecuniary sense. The bell-founder's art is wholly distinct from that of the clockmaker, and is not likely to be improved by any suggestions of the latter party.

Remarks upon the Specification.

1st. There is a circumstance connected with the manner in which it is proposed the clock should strike the quarters, which demands particular notice, namely, Mr. Dent's disregard of the Architect's instructions respecting the number of bells on which the quarters were to be struck. Mr. Barry, in the very first letter which appears in this correspondence, requires that the clock should "*chime the quarters upon eight bells.*" Of this requisition not the slightest notice is taken. Mr. Dent uniformly proposes that the clock should strike the quarters upon only two bells, which is the most common mode applied to public clocks. There are several clocks in the metropolis which strike the quarters upon four bells,† and very recently a clock has been put up in Scotland, by which the quarters are struck upon six bells. Mr. Barry proposed eight bells to distinguish this clock from all others in the metropolis, and as the best mode that could be adopted for that purpose, Mr. Whitehurst, in his specification, proposes to strike the quarters upon five bells, in preference to eight, but he assigns his reason for so doing. It is difficult to understand why Mr. Airy, as referee, should have permitted so glaring a deviation from the instructions on which the plans and specifications were to be founded. So far as the exact measurement of time is concerned, it matters not what number of bells the clock strikes upon: it is entirely a question, first, of power in the machine, and next, of expense in the construction.

Mr. Dent, for obvious reasons, deviated from the instructions laid down, but he had no authority from the Board, or from the Astronomer Royal, for such deviation; and it is to be observed that this alteration in the mode of striking the quarters seriously affects the comparison of the estimates which were furnished by other parties.

* See Appendix No. 3. † See Appendix No. 4.

3rd. The fixing of the frame, containing the bevel-wheels which communicate the motion from the clock to the hands, to a cast-iron girder built into the walls above the centre of the dials, is a necessary consequence of placing the clock so low in the tower, and is, under any circumstances, an exceedingly inconvenient and injudicious arrangement. Mr. Dent does not make himself understood when he says "*the barrel to be so constructed that the hands will keep going while winding up the auxiliary weight.*" This is mere assertion of a fact assumed; but it is not shown how the fact is to be accomplished: the language of a specification should be clear and explicit.

6th. The proposal to employ a two-seconds pendulum is not new. The shape of the bob is not very material; the weight here specified is considerable, though a heavier weight has been used. It is also worthy of notice that Mr. Dent's intention was to suspend the pendulum from the wall, and, consequently, to place the clock likewise close against the wall, which is an exceedingly faulty arrangement; inasmuch as it precludes the possibility of access to that side of the clock, and it is essential that the clock should be accessible on all sides.

7th. Much stress is laid by Mr. Airy on the use of a remontoire escapement: upon this the following remarks present themselves. It is well known, that when a remontoire is applied to a chronometer, a considerable portion of the maintaining power is absorbed by it; for, supposing two chronometers to be exactly similar in all other respects, but that the one has, and the other has not, a remontoire, the former will not carry nearly so heavy a balance as the latter; or, if the balances be of equal weight, the maintaining power of the watch with the remontoire will require to be very much increased. The clock at the New Royal Exchange is probably the only public clock in this country to which a remontoire (though very common in France) is now applied. Reasoning by analogy, it follows that, with this addition, a great increase of the maintaining power will be required; the wear and tear will be proportionably increased, and the durability of the clock seriously affected: it is proposed, therefore, to incur a positive evil to obtain a very questionable advantage. As regards the weight of the maintaining power of the going part of the Royal Exchange clock, or of that which it is proposed to employ for this clock, not the smallest intimation is given in any of Mr. Dent's specifications, or in Mr. Airy's conditions or inquiries.

9th. The making the minute hand advance by starts 3·84 inches at a time every 20 seconds, certainly possesses the merit of novelty; but the more than probable disadvantages which may result from it, are shown in Mr. Vulliamy's remarks on Mr. Airy s specification at page 19.

On the Mode of Winding the Clock.

As far as can be collected from Mr. Dent's specifications, he has not made any provision for winding the clock otherwise than in the usual manner, which, in the case of very large clocks, is frequently attended with much inconvenience. The twisting of the winding-up square of the striking parts of a large clock, caused by the great weight to be raised, is an accident of frequent occurrence, and one the remedying of which is attended with much trouble and expense. It can only be done by unmounting the arbour, and removing the barrel and great wheel, making a new arbour, and remounting them upon it; and when that is done, there is no security against the recurrence of a similar accident. To obviate this, as far as is practicable, the winding-up square is made very large. Now, as the size of the square determines the size of the pivot, which is a circle circumscribing the square, it necessarily follows that the pivot is made much larger than it otherwise need be, and that the friction is much increased in consequence. In the case of a very large clock, the best mode of winding is by a separate wheel and pinion; the wheel being fixed to the barrel at the reverse end from the great wheel, and the pinion mounted upon an arbour, which is placed in gear with the wheel. The arbour is pivoted between two cocks attached to the frame, one end of which is squared to receive the winder. In the event of an accident happening to this square, a new arbour is very easily substituted for the old one, and at a very small expense, compared to the cost of a new barrel arbour, without interfering with the rest of the work, and without the delay that would necessarily ensue. This mode of winding is expressly noticed and provided for in Mr. Vulliamy's and Mr. Whitehurst's plans and specifications.

Mr. Whitehurst's Tender.

1846, Sept. 24. No. 21.

Mr. *Whitehurst* to the *Commissioners of Woods and Forests.*

Sir, Derby, September 24, 1846.

I beg to offer to Her Majesty's Commissioners of Woods, &c., my plan, specification, and estimate for the great clock for the New Houses of Parliament, in conformity with their kind permission for me to do so.

I have constructed the clock to strike the hours upon a bell 14 tons weight, agreeably to their instructions, and to strike the three quarters upon five bells in proportion to the great bell. I have chosen five bells, in preference to any other number of bells for the quarters, as it will be a good distinction from the rest of the public clocks in London, some of which strike the quarters upon two bells, and some of them upon four bells. Five bells will make a pleasing sound for the quarters, more suitable than eight bells, which will be too jingling; the public will not know whether the clock is striking, or whether the ringers are ringing the bells, if there are eight of them.

I have constructed the clock to strike the three quarters only, and not the fourth quarter at the hour. I think it will be more noble and more grand to let the great bell thunder out the hours alone; and it will be a proper distinction between the hours and the quarters, and by which the clock will not appear too jingling, but positively useful, and it will also ensure the first blow of the hour hammer to strike to a second of time, agreeably to the instructions of the Astronomer Royal. The clock to show the hours and minutes upon four dials, 22 feet diameter, with a pair of copper hands to each dial, with suitable dial works, bevel works, and universal points; the escapement to be a dead escapement, and the pendulum compensated either with mercury or any other substance the Astronomer Royal may think fit. The wheels and bushes to be made of hard red brass, the pinions and pallets to be hard, the works to be fitted into a strong iron frame, well and firmly screw-bolted together; the whole of the works to be made as well as the best materials and hands can make them, and entirely to the satisfaction of the Astronomer Royal, with suitable hammers to the bells, with weights, ropes, and pulleys. Reference is made, in the conditions to be observed in regard to the construction of this clock, to study the construction of the Royal Exchange clock. This clock I have had no means of seeing, but shall be most glad to receive any instructions from the Astronomer Royal relative thereto. I have, in consequence, omitted putting my escapement into the plan of the clock, but have brought with me one of the escapements I usually put to large clocks, for the inspection of the Astronomer Royal; and should he not approve of it, I shall feel obliged to him if he will give me a plan of the escapement he wishes to have made to the clock, and I will put it into my plan of the clock. The great wheels of the striking part and the quarter part to be 3 feet diameter; the great wheel of the going part to be 18 inches diameter; the remainder of the wheels to be in proportion agreeably to my plan of 2 inches to the foot scale. I strike the hours from the great wheel, and the quarters from a chime barrel that makes one revolution in two hours. I put strong wind-up wheels to the striking and quarter parts.

I will engage to make the clock, with my own time, journeys, and expenses, to superintend the completion of it, with the use of packages, and delivered carriage free at the Houses of Parliament, for the sum of 3373*l.*

The above sum does not include the dials, nor the painting and gilding them and the hands, nor the joiner's work, mason's work, nor scaffolding, which are to be paid for extra. I will do myself the honour to wait upon you with the plan to-morrow, and give you any further information in my power; and should I be so fortunate to receive the order for the clock from Her Majesty's Commissioners of Woods, &c., they may depend upon my best exertions, and I shall feel myself highly honoured.

I have, &c.,
(Signed) *John Whitehurst.*

N.B.—The striking part and the quarter part of the clock to go four days with once winding up, the going part to go eight days with once winding up.

(Signed) *John Whitehurst.*

Note.—This estimate is superseded by the amended estimate (inserted in the previous return), including the sum of 150*l.* for the electro-magnetic apparatus subsequently proposed by the Astronomer Royal, making the total amount of Mr. Whitehurst's tender 3,523*l.*

1846, Nov. 7. No. 22.

Mr. *Dent* to *T. W. Philipps*, Esq.

Sir, 33, Cockspur-street, November 7, 1846.

I beg leave to inform you, for the information of the Astronomer Royal, that it is customary for all the bevel wheels which drive the hands in large public clocks to be fixtures on their axles; and the adjustment of the pointing of the minute hands, with reference to the striking of the hour, is made by shifting the bevel wheels one or more teeth. As this mode of alteration can only produce a near approximation to the minute, I propose, for the approbation of the Astronomer Royal, that the axles which carry the four minute hands should have the bevel wheels on each so fitted as to admit of a small circular adjustment by means of screws acting near to the periphery of the wheel. By this plan the minute hands can be made to indicate the letting off the remontoire, and the striking of the first blow of each hour exactly.

I have, &c.,
(Signed) *Ed. J. Dent.*

The difficulty on which Mr. Dent expresses himself so obscurely, if not unintelligibly, is one which has not escaped the attention of former clockmakers; and it has been perfectly overcome by means more simple than Mr. Dent attempts to describe.

1846, Nov. 13. No. 23.

Professor *Airy* to *Alexander Milne*, Esq.

Royal Observatory, Greenwich,
November 13, 1846.

Sir,

HAVING examined the plan and specification offered by Mr. John Whitehurst for the great clock for the New Palace at Westminster, I find that there are several points upon which I desire information or upon which I wish to remark. Of these I subjoin notes: and I have the honour to request that, if you shall think such a course desirable, you will transmit these or any part of them to Mr. Whitehurst, and that you will ultimately communicate to me his replies.

I have, &c.,
(Signed) *G. B. Airy.*

PROFESSOR AIRY'S NOTES upon the PLAN and SPECIFICATION offered by Mr. JOHN WHITEHURST for the GREAT CLOCK for the NEW PALACE at WESTMINSTER.

1. The plan is generally imperfect, giving little information, even on the grand arrangements, and omitting many details of the smaller parts.
2. There is no ground plan or horizontal plan, and nothing showing the place in the tower in which Mr. Whitehurst proposes to place the clock, or the way in which he proposes to support it, whether by iron girders or cantilevers, or in what way. I should wish to see these, and to understand whether the expense of the supports is included in the tender.
3. In regard to the going part, I should be glad if Mr. Whitehurst would send to me the specimen or model of escapement to which allusion is made in his specification.
4. At the same time, I remark that it does not appear that the plan includes any remontoire construction (as required in my condition, No. 7).
5. Neither does it appear that the plan includes a going barrel.
6. In regard to the striking part, there is no description of the method of unlocking, and no security whatever that the condition No. 11 (for accurate striking of the first blow for each hour) will be rigorously complied with.
7. I cannot undertake to sanction the omission of the quarter striking before the full hour.

November 13, 1846. (Signed) *G. B. Airy.*

1846, Nov. 13. No. 24.

G. B. Airy, Esq., to *Alexander Milne*, Esq.

Royal Observatory, Greenwich,
November 13, 1846.

Sir,

HAVING examined the plan and specification for the great clock for the New Palace at Westminster, offered by Mr. E. J. Dent, as well as the remarks for consideration submitted by him, I have the honour to transmit to you my opinions on the points to which the remarks apply, and my notes on the plan, &c., in general; and I request, that if you shall consider such a course desirable, you will transmit these notes or any part of them to Mr. Dent, and that you will ultimately communicate to me his replies.

I have, &c.,
(Signed) *G. B. Airy.*

PROFESSOR AIRY'S OPINIONS on Mr. DENT'S "Remarks for Consideration," in reference to the GREAT CLOCK for the NEW PALACE at WESTMINSTER.

1. I think it desirable that preparation be made for driving the hands by an auxiliary weight (as the apparatus would not be expensive); nevertheless I would prefer not to use it if it is not absolutely necessary. No plan is given for a going barrel, as used with this auxiliary weight.
2. I entirely approve of the fly, in reference to the stopping of the remontoire action. It must be furnished with ratchet and click.
3. The proposed means of regulation are satisfactory.
4. There is nothing which calls for remark, except as will be mentioned below. The locking plate is the proper construction.
5. I should prefer iron hands if they could be made, but I doubt whether zinc-covered iron can be gilded, as the application of the nitrate of mercury, if effective for amalgamation, will injure or destroy the zinc.

6 and 7. Allusion will be made below to the supports, &c.

8. Probably by galvanic communication the other clocks in the building can be made to depend on this, but I think in no other way.
9. I have no authority to give an opinion on this proposal.

NOTES on Mr. DENT'S PLAN, &c.

1. A ground plan is wanting, as also a plan distinctly pointing out the position in the tower which Mr. Dent proposes to take.

2. It would seem from the plan, No. 1, that the vertical shaft giving motion to the hands drops within the clock frame. If this is correct, the proposed corbels for supporting the clock must be very long. I should prefer cross girders.

3. I desire explanation on the practicability of taking out each wheel separately.

4. The thickness of the wheels is not given.

5. In the going train the second wheel appears to have no purpose but to communicate motion to the third wheel of an equal or nearly equal number of teeth. If this is so, that wheel is unnecessary, as the going barrel can be adopted (by changing the form of its lever) to work immediately in the hour wheel.

6. It appears that the barrel for the striking train is only one foot in diameter, and that in one turn it strikes 48 blows. As it is understood that the blows must be very heavy, I can hardly conceive this to be sufficient, without an immense weight. I desire full particulars of the weight and fall of the hammers, weight and fall of the weights, and such calculation (referring to other clocks if necessary) as will show that sufficient provision is made here.

7. I should be glad to know whether the wire rope has been tried for similar purposes.

8. I do not understand whether the hands are fixed or are adjustible.

9. The galvanic arrangement proposed by Mr. Dent is suitable for giving motion to other clocks, but is not suitable for the special object of my condition, No. 12.

Nov. 13, 1846. (Signed) *G. B. Airy.*

Observations on Mr. Airy's Opinions on Mr. Dent's "Remarks for Consideration," "Notes on Mr. Dent's Plan, &c.," and "Supplementary Notes on Mr. Dent's Plans, Specifications, and Suggestions."

Article 5th. On the "*Opinions.*" Mr. Airy need not have doubted "*whether zinc-covered iron can be gilded;*" for it is well known that iron can be gilt by no other process but that called oil-gilding. There are many objections to iron hands; for however well they may be painted and gilded, the iron will always, in time, become exposed, and liable to rust: copper is, in every respect, a preferable material for this purpose.

Article 6th. Of the "*Notes.*" A wheel striking 48 blows every revolution would be required to make 26 revolutions to strike 8 days and nights; and the cams, to raise the hammers, must be placed 24 on each side of the wheel, which renders two hammers necessary. A cylinder of 1 foot in diameter is about 3 feet $1\frac{3}{4}$ inches in circumference, which, multiplied by 26, the number of the revolutions required, gives 81 feet 9 inches for the fall required for the weight, if suspended by a single line; but this clock is proposed to be placed in a tower that would allow of a fall of considerably more than 150 feet. Now, supposing the weight suspended by a double line, (the mode usually adopted,) a barrel 2 feet in diameter might be employed, or, with a suspension by a treble line, a barrel 3 feet in diameter. It is scarcely necessary to notice that, by whatever number of lines the weight is suspended, the portion acting upon the clock is the same. If, as is here supposed, a hammer is raised by a cam on each side of the wheel, and that, consequently, two hammers are employed, both will be, more or less, in action at the same time; whence it follows, that the draft will be so much the greater upon the clock, and that the weight employed, (which, with so small a barrel, must, under any circumstances, be very great,) will need to be still further increased to meet this resistance.

Article 11th. Of the "*Supplementary Notes.*" Mr. Airy allows that he considers the going train too small; and certainly when the relative dimensions of the tower of the Royal Exchange, and that of the New Palace, are contrasted, it must appear absolutely ridiculous to think of placing in the tower of the New Palace a clock so comparatively diminutive as that of the Royal Exchange. The dials of the Royal Exchange clock are 9 feet in diameter, which is about one-third of the size of the dials proposed for this clock. The size of the going part of a public clock is principally determined by the size and number of the dials; and it follows, of necessity, that to preserve the relative proportions between the parts of the clock, the wheels of the New Palace clock should be about three times the diameter of those of the Royal Exchange clock. Yet Mr. Dent actually proposes to cast the work of this clock from the same patterns as that of the clock at the Royal Exchange, in order to "*occasion a great saving of expense.*" See his letter to the Commissioners of Woods and Forests, dated the 14th November, 1845.

It appears by Mr. Airy's "*Opinions*" and "*Notes,*" that he did not consider Mr. Dent's

specification as by any means complete or satisfactory. He has adverted to some of its defects; but he certainly might have pointed out many other points and omissions which are quite as objectionable. He takes no notice of the deviation from Mr. Barry's requisition, as to the number of the quarter-bells, or of the want of a description of the mode of winding up the striking parts; nor of many other points which might be alluded to.

When Mr. Airy wrote these "*Opinions on Mr. Dent's Remarks for Consideration*," and furnished these "*Notes*," he was in possession of Mr. Vulliamy's and Mr. Whitehurst's specifications and drawings.

1846, Nov. 13. No. 25.

G. B. Airy, Esq., to *Alexander Milne*, Esq.

Sir, Royal Observatory, Greenwich, Nov. 13, 1846.

I HAVE the honour to acknowledge your letter, 8355, of the date of 12th November, enclosing copy of a letter from Mr. Dent, dated 7th November, containing suggestions relating to the great clock for the New Palace at Westminster.

In reply, I have the honour to subjoin notes, which I request may be considered as supplementary to those which I transmitted with my former letter of this date, and which in like manner it may, perhaps, be desirable to transmit to Mr. Dent.

I have, &c.,
(Signed) *G. B. Airy.*

SUPPLEMENTARY NOTES on Mr. E. J. DENT'S PLANS, SPECIFICATIONS, and SUGGESTIONS for the GREAT CLOCK for the NEW PALACE at WESTMINSTER.

10. Mr. Dent's suggestions of an adjusting power for the position of the clock hands, to be applied near to the periphery of each of the bevelled wheels, appears to me proper for adoption. I think, however, that besides the security of the screw acting endways (which his proposal seems to contemplate), there should also be the security of clamp screws.

11. The dimensions of the going train of the clock appear to me to be generally small. I should be glad to be furnished with a comparison of the dimensions of the wheels, &c., with those of the clock on the Royal Exchange.

12. I wish to know whether the expense of the supporting girders or corbels is covered by the tender.

Nov. 13, 1846. (Signed) *G. B. Airy.*

1846, Dec. 28. No. 26.

Mr. *Dent* to *T. W. Philipps*, Esq.

Sir, 33, Cockspur-street, Dec. 28, 1846.

I BEG leave most respectfully to acquaint you, for the information of the Commissioners of Her Majesty's Woods and Forests, that herewith are forwarded 10 diagrams in illustration of the answers to the questions put to me by the Astronomer Royal. As it has been necessary to increase the scale of the proposed clock in several parts to meet the conditions required by Mr. Airy, it becomes requisite that I should state, for the satisfaction of the Commissioners, that I still adhere to the original estimate.

Permit me further to acquaint you that I have supposed the bell to be about the same weight as that at Christ Church, Oxford, which is about seven tons; perhaps I may be allowed to add, that it has been doubted by eminent mathematicians whether the shape of a movable bell, as used for church tolling, is the proper form for a stationary bell to be struck by a hammer; and as the bell in question is one of the latter description, I must respectfully suggest that Professor Wheatstone's opinion be requested on the subject; that he be appointed the referee on the part of the Commissioners in deciding on the tone, &c., of the bell; and that his certificate be declared necessary before it shall be placed in the tower.

I have, &c.,
(Signed) *Ed. J. Dent.*

PROFESSOR AIRY'S OPINIONS on Mr. DENT'S "Remarks for Consideration," in reference to the GREAT CLOCK for the NEW PALACE at WESTMINSTER.

	Answers.
Preparation shall be made for the adoption of an auxiliary force; but as the Astronomer Royal approves of the introduction of a fly at the remontoire, I am of opinion that the auxiliary force will not be required.	1. I think it desirable that preparation should be made for driving the hands by an auxiliary weight (as the apparatus would not be expensive); nevertheless I would prefer not to use it, if it is not absolutely necessary. No plan is given for a going barrel as used with this auxiliary weight.

Answers.

A click and ratchet shall be applied as requested.

2. I entirely approve of the fly, in reference to the stopping of the remontoire action. It must be furnished with ratchet and click.

3. The proposed means of regulation are satisfactory.

4. There is nothing which calls for remark, except as will be mentioned below. The locking plate is the proper construction.

The gilding of the hands and figures on the dial plate is effected by using gold size, and then laying on it the gold leaf.

5. I should prefer iron hands if they could be made; but I doubt whether zinc covered with iron can be gilded, as the application of the nitrate of mercury, if effective for amalgamation, will injure or destroy the zinc.

6 and 7. Allusion will be made below to the supports, &c.

8. Probably by galvanic communication the other clocks in the building can be made to depend on this; but I think in no other way.

9. I have no authority to give an opinion on this proposal.

Notes on Mr. Dent's Plan, &c.

Ground plan and position.

1. A ground plan is wanting, as also a plan distinctly pointing out the position in the tower which Mr. Dent proposes to take.

The use of corbels is superseded, as shown in diagram No. 9.

2. It would seem from the Plan No. 1, that the vertical shaft giving motion to the hands drops within the clock frame. If this is correct, the proposed corbels for supporting the clock must be very long; I should prefer cross girders.

If two wheels are placed in the same support, the gun-metal bearing can be taken out to allow of the wheels being removed.

Thickness of wheel is given in diagram No. 6.

3. I desire explanation on the practicability of taking out each wheel separately.

4. The thickness of the wheels is not given.

The two wheels are the same size, and were put to keep the going barrel in the same horizontal line. Perhaps Mr. Airy will please to supply a sketch to avoid it.

5. In the going train the second wheel appears to have no purpose but to communicate motion to the third wheel of an equal or nearly equal number of teeth; if this is so, that wheel is unnecessary as the going barrel can be adapted (by changing the form of its lever) to work immediately in the hour wheel.

The particulars of weights, fall, and hammers are given in diagrams, from 1 to 6.

6. It appears that the barrel for the striking train is only one foot in diameter, and that in one turn it strikes 48 blows. As it is understood that the blows must be very heavy, I can hardly conceive this to be sufficient without an immense weight. I desire full particulars of the weight and fall of the hammers, weight and fall of the weights, and such calculation (referring to other clocks, if necessary), as will show that sufficient provision is made here.

Wire rope is now generally used in clocks. I have never seen any alteration in the wire rope in the Exchange clock; it is as perfect as when applied. The patentee warrants it to bear 18 cwt. with perfect safety, half-inch diameter. Hempen rope would be one and a half inch or two inches diameter, and would require new ropes every three years, and always liable to break.

7. I should be glad to know whether the wire rope has been tried for similar purposes.

The minute hand is movable by means of a flange on the back of a two-inch wheel, and in the present case a clamping screw will be added for security.

New arrangement shown in diagram No. 6.

8. I do not understand whether the hands are fixed or are adjustible.

9. The galvanic arrangement proposed by Mr. Dent is suitable for giving motion to other clocks, but is not suitable for the special object of my condition.

Supplementary Notes.

Clamp screws shall be added.

10. Mr. Dent's suggestions of an adjusting power for the position of the clock hands, to be applied near to the periphery of each of the bevelled wheels, appears to me proper for adoption. I think, however,

Answers.

The drawing originally sent is to half size of the clock of the Royal Exchange. The weight of the hammer I calculated to raise near about 60 lbs. The diagram No. 6, is intended to meet the suggestions of the Astronomer Royal.

Neither the supporting girders or corbels were included in the tender, nor is the cast-iron frame which supports the clock in diagram No. 9, as shown at *i*.

Royal Observatory, Greenwich,
13 November, 1846.

that besides the security of the screw acting endways (which his proposal seems to contemplate), there should also be the security of clamp screws.

11. The dimensions of the going train of the clock appear to me to be generally small. I should be glad to be furnished with a comparison of the dimensions of the wheels, &c., with those of the clock on the Royal Exchange.

12. I wish to know whether the expense of the supporting girders or corbels is covered by the tender.

(Signed) *G. B. Airy.*

List of Diagrams.

1. Camberwell clock.
2. Royal Exchange clock.
3. Wilton-place clock.
4. Christ Church Oxford clock.
5. St. Paul's Cathedral clock.
6. Proposed clock, to go eight days.
7. Proposed clock, to go four days.
8. Ground plan of No. 6.
9. Fixing of clock.
10. Correction of tracing.

The Astronomer Royal's opinions are respectfully requested on the following subjects:

1. Should the clock go four or eight days?
2. Mr. Airy will please to supply a mere sketch of his going fusee to dispense with the extra wheel.
3. Is the let-off by electricity satisfactory?
4. Opinion on lantern pinions.
5. Position of hammer to strike bell.
6. Should barrels be tapered or left cylindrical?

References to Ground Plan.

a. Stone corbels. The clock will now stand on the main walls.
b. Large frame.
c. Small frame, standing on the top of *b*.
d. Locking plate.
e. Locking piece on fly pinion axle.
f. Fly.
g. Cams.
h. Striking lever.
i. Bevel wheels of 20-inch diameter.
k. Expansion joint.
l. Hour lever.
m. Hour snail.
n. Minute snail.
o. Pendulum bob.
p. Ditto suspension.

Reference to Diagram for fixing Clock.

a. Wall.
b. Staircase.
c. Stone to receive pendulum support.
d. Pendulum support.
e. Pendulum.
f. Trap-door, which will allow of walking round the clock.
g & *g*. Mr. Airy will please say which figure he prefers.
h. Two cast-iron girders, passing over the opening D, on which is screwed the frame to receive clock.
i. Frame to receive clock.
k. Screws to secure clock on the stone.

Table explanatory of Diagrams.

Number for Reference in Diagrams.	Name of Church.	Diameter of Barrel.	Weight or first Power without Pulley.	Power of Cams.	Height of Hammer raised.	Weight of Hammer at about 35°.	Excess of Power to raise Hammer, and which goes to drive the Fly.	Weight of Bell.	Number of Days going.	Fall of Weight.
		Inches.	lbs.	lbs.	Inches.	lbs.	lbs.	cwts.		Feet.
1	Camberwell . . .	10·5	186	35	4·5	22	4	26	8	33½
2	Royal Exchange .	13 0	392	83	6·0	34	6½	56	8	50
3	Wilton Place . .	4·15	224	98	5·0	24	4	26	8	34½
4	Christ Church, Oxford	9·5	103	49	4·5	54	4½	152	1	29
5	St. Paul's, London .	20·0	504	360	10·0	115	56	102	1	33½
6	Proposed Clock . .	22·0	337	260	6·0	120	8	152*	8	134†
7	Ditto	22·0	296	232	10·0	130	6½	152*	4	134†

Remarks.—The weight and fall are given as direct. Example: St. Paul's has one pulley, the weight is 9 cwt., and fall 134 feet. In the table the weight is 504 lbs and 33 feet fall, half the weight and fall being deducted for the moveable pulley.

* The same weight as the bell at Christ Church, Oxford. † This Table was arranged before the inquiry respecting the room under the clock was made. The fall now is 195 feet.

16th December, 1846.

(Signed) *Ed. J. Dent.*

Remarks on the Table.

The clocks Nos. 1 and 2 have been recently constructed by Ed. J. Dent. The measures, as exhibited in the drawing, may be fully depended upon; but so unsatisfactory is the information to be obtained respecting the structure of most public clocks, that the result of the inquiries made is not worthy of being here detailed. A most usual practice prevails of increasing the weight, with the view to overcome defects in mechanical construction. The following instances will, perhaps, elucidate my meaning, The church clock in Waterloo-road has a striking weight of 15 cwt., with pulley; and the clock put up in Windsor Castle, by order of George the Fourth, has, I believe, a similar weight. It appears from the table, that (to use technical language) there is nearly a uniformity in the work done by the clocks Nos. 1, 2, 3, and 4. The clock No. 3 is one also constructed by E. J. Dent, having cast-iron wheels, in which the hammers are raised without driving through a pinion, as in Nos. 1 and 2. Ten cams are cast on both sides of the wheel, so that two hammers of 24 pounds each are being raised nearly at the same time, and which will account for the power at the cams being 98 pounds, or 49 pounds* for each hammer. The two next clocks are the most important for comparison; viz. that at Christ Church, Oxford, and that at St. Paul's Cathedral, London. The information about to be given respecting the clock at St. Paul's, is supplied by a workman in my employ, who partly reconstructed it some years since, and attended the experiments made on the bell. From the table there appears to be a great discrepancy in comparing the diameters of barrels, weights, lift of hammers, weights of hammer heads, and weight of bells. The statement given by the workmen will explain much of the apparent want of agreement. The bell of St. Paul's is allowed to be a bad bell for sound, a defect arising from it being too thick; whilst that at Christ Church is more perfect, both as regards sound and figure. When the clock of St. Paul's was thoroughly repaired experiments were made with a view of obtaining as much sound from the bell as possible. The authorities of the cathedral placed themselves on Blackfriars Bridge, and after hearing the effect produced by various heights and weights of hammer, the present arrangement was adopted, viz.: 10 inches of fall and 140 pounds for the hammer. The bell at Christ Church is one-third heavier, the fall of the hammer being four inches and a half, and its weight 77 pounds. The original clapper is about the same weight. After the above-mentioned experiments on the bell at St. Paul's, it was determined, without sufficient consideration being paid to the mechanism, that the first power should be increased to 504 pounds, thereby appending a weight to the works of the clock which never could have been originally intended. This is evident from the noise produced when the train is in motion; a sufficient indication that the teeth must be wearing out through the friction occasioned by excessive weight. In the Royal Exchange clock, on the contrary, the motion of the train is unattended with the slightest noise. There is to be observed, on inspecting the diagrams of the two clocks, a manifest proof of power lost in St. Paul's. The calculation shows that the first power could raise a hammer of 171 pounds, while the weight is only 124 pounds. A force of 56 pounds, therefore, is expended in driving the fly, and making a noise among the wheel teeth. In the clocks, 1, 2, 3, and 4, the first power at cams gives nearly the weight of hammer raised, leaving a mean of about five pounds to drive the flies. The two next for consideration are clocks proposed to be constructed from diagrams exemplifying suggestions made by the Astronomer Royal in his communication of 13th November, 1846. No. 6 is a diagram to size of the striking part of an eight-day clock. The only remark which it may be necessary to offer in addition to the drawing has reference to the letting-off of the striking part by an electric current. There is an adjustment added to the end of the lever, as shown at *a*, to allow of the arm being shortened, so that the clock may be put on the morning 20 seconds before the time to be sounded; for if the clock were slow but the fraction of a second the warning would not be raised in time for the let-off by the electric force.

The sketch No. 7 is for a clock to go four instead of eight days. A weight of 296 lbs. at first power will raise a hammer of 130 lbs. ten inches in elevation. It must, however, be considered that the velocity of the first wheel is hereby increased, and supposing the interval between the blows to be four seconds, and 13 cams on the first wheel, it will make one revolution in 52 seconds. In the eight-day clock, No. 6, there are 26 cams, equal to one minute 44 seconds for each revolution. It would appear that the wear on the wheel teeth, and cams, is double to that which takes place on No. 6, arising from the increased velocity, as in this case the wear will be on 13 cams, whilst in the eight-day clock it is distributed over 26 cams. The Astronomer Royal will, perhaps, express his opinion of the two clocks Nos. 6 and 7.

Position of Hammers.—As hammers are usually placed, the force of the hammer decreases in elevation, while on the contrary the force of the clock increases, as shown in the diagram No. 7, at *b*. In the other method, when the hammer is suspended as represented at *a* and *à*, the force both of the clock and hammer is increasing. The Astronomer Royal will please to signify his opinion which of these two methods of striking the bell he deems preferable.

Pinions.—From the great body of steel contained in the centre of the large pinions, compared with the leaves, it becomes almost impossible to harden the mass equally, as from the difference of bulk in the materials the leaves break off in the process of hardening. Clockmakers usually make the large pinions of gun metal, but the wheel and pinion, when both constructed of this metal, do not wear well. I, therefore, respectfully propose for Mr. Airy's judgment, whether the large pinions should not be lantern shape, having the leaves pivoted into a frame, similar to the pinions in Harrison's first chronometer. In all the large public clocks on the Continent, the lantern pinions are used, and in the clock of the Hotel de Ville of Paris they are pivoted in as suggested above. In this clock, although the curve on the wheel teeth can have no pretensions to any mathematical accuracy, being filed up by hand, still, under this great defect, there is not, after 60 years' performance, the slightest appearance of wear either on the face of the teeth or in the pivot-holes of the leaves. The weight of the first power is 350 lbs.

Barrels.—The circumference of the barrels will be tapered to compensate for the weight of the wire rope. 138 feet weighs 20 lbs. Mr. Airy will please say if the tapering be necessary.

* The clock only raises the hammer three inches, therefore the leverage increases between the clock and the hammer.

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Fixing of Clock.—From the tracing which accompanied the specification, it was shown that the "room under clock room" was 14 feet wide. As this measure did not agree with the others, I applied at the architect's office, and it seems that in the 14 feet there are to be two outside walls and staircase, which reduces the room to a continuation merely of the space below for weights, as shown at D. As the height of this "room" is not taken into consideration in the drawings herewith sent, it will be necessary to make an alteration in the calculation, so as to make use of the 45 feet fall to gain more power. The fall will now be 195 feet instead of 150 feet.

(Signed) *Ed. J. Dent.*

December 24, 1846.

In this letter to Mr. Philipps, Mr. Dent recognises the necessity that the scale on which the clock was proposed to be made should be increased, yet he says he will "*adhere to the original estimate;*" from all which it is to be deduced that Mr. Dent can make a very large clock at the same price as one which is comparatively small. If Mr. Dent can make a clock, on the scale required for dials of 27 feet in diameter, at the same price as one for dials of 9 feet, he certainly ought, for economy's sake, to be allowed to do so; and if he can make it well on such terms, so much the better.

It has already been shown that a clock of the size proposed by Mr. Dent in his original specification would have been utterly inadequate. Mr. Dent, probably doubting the power of the clock upon the scale given in his first specification, now proposes that it should strike upon a bell of even smaller weight than the minimum required by Mr. Barry, who defines the weight of the bell as eight or ten tons. His doubts respecting the shape of the bell are quite beyond the province of the clockmaker; the bells might safely be left in the hands of the bell-founder, whose interest, as well as business, it is to make himself master of his art. It does not appear why Mr. Dent suggests that Professor Wheatstone should be appointed referee upon the bells; it may possibly, however, be attributed to a desire, after having obtained authority to order the bells (as proposed in his letter and remarks of August 8th, 1846), to avoid the consequent responsibility. This is the second time Mr. Dent proposes a reference, and nominates the referee.

Observations upon "Remarks on the Table."

In illustration of his remark that "*a most usual practice prevails of increasing the weight with the view to overcome defects in mechanical construction,*" Mr. Dent cites, first, the church clock in the Waterloo-road, the striking weight of which, he says, is 15 cwt., with pulley, implying that the weight is hung by a double line; secondly, the clock put up in Windsor Castle, which, he says, "*has, he believes, a similar weight.*" But Mr. Dent does not state the fact, that the fall for the Windsor Castle clock weight is very limited, and that, consequently, it was necessary to suspend the weight by four lines, which, of course, compels an increase of the maintaining power. Nevertheless, the weight acting upon the clock to raise the hour hammer is no greater than if it were suspended by a single line; and, in reality, amounts to no more than 3 cwt. 2 qrs.

Mr. Dent cannot pretend to say that, in this instance, the weight has been increased to "*overcome defects in mechanical construction;*" and if he did not intend his remarks to be understood in this sense, he was not justified in naming this clock.

As to the position of the hammers, it may be observed that Mr. Dent has simply described the French method of raising them in distinction from that of the English clockmakers.

Mr. Dent, in alluding to the clock at the Hotel de Ville, at Paris (which he has done under the head of "*Pinions*"), has omitted to notice one very material circumstance, viz., that this clock is wound *daily*. If a weight of 350 lbs., as stated by Mr. Dent, be required for a thirty-hour clock, what weight would be required for an eight-day clock of similar power? Under these circumstances, therefore, would lantern pinions have possessed the requisite strength, and (what is yet more important) would they be strong enough for the clock projected for the New Palace at Westminster? It is a mistake to assert that clockmakers generally form their large pinions of gun-metal; they generally make them of iron, and afterwards case-harden them. Gun-metal wheels and pinions act extremely well together, provided sufficient attention be paid to the quality of the metal of which they are made.

In reference to barrels, Mr. Dent can easily make the experiment as to how far the

intervals between the blows will be diminished by the increased weight of the line, by merely adding 20 lbs., (which, he states, will be its weight,) to 392 lbs., that of the striking weight of the clock at the Royal Exchange (see the table), making a total of 412 lbs.; and then, having ascertained the time, in seconds, occupied in striking 12 blows, with the original, and with the increased weight, he will discover that their difference, divided by 12, is a portion of time too small to be perceptible to the ear. All that is stated in reference to tapering the barrels is utterly absurd.

This may be considered as a second specification furnished by Mr. Dent.

1847, January 2. No. 27.

Mr. *Whitehurst* to the Hon. *C. Gore.*

Sir, Derby, January 2, 1847.

I HAVE the honour herewith to send you a ground plan and an end view, with the connecting wheels, to the four dials of the great clock for the New Houses of Parliament, as required by the Astronomer Royal, with the answers to his notes, No. 8537, 13th November, 1846, as far as my humble ability is capable of.

Answers.

Note 1.—The plan I gave in is a working-man's plan, called a calliper, which gives the dimensions of all the material parts.

Note 2.—I have sent the ground plan required, and also an end view of the clock, showing where I should place the clock in the tower to suit the space to receive lines and weights, as specified in the plan of the tower given to me. I have also attached a plan of the end view of the clock, showing where I strongly recommend the clock to be placed, and for that purpose to remove the space to receive lines and weights more to the east three feet four inches and a half; this will allow of the upright shaft at the back of the clock to communicate direct up to the centre bevel wheels, which are placed in the centre of the tower, to give motion to the hands of the four dials, and will do away with the connecting bevel wheels, which is desirable in many respects; but the great advantage to be derived by removing the space to receive weights and ropes more to the east, and consequently the clock, will be the good elbow-room it will give at the back of the clock, where much of the works are placed, particularly the pendulum and escapement; it will also afford better means of getting light to the back of the clock, which I apprehend will be the dark side of the room, from the near approach to the wall of the air flue. I most strongly recommend the clock to be placed agreeably to my suggestions.

I should place the clock upon two cast-iron beams, as shown in my ground plan, that will reach across the tower from north to south; the expense of which beams is not included in my tender; I consider them belonging to the building.

Note 3.—The escapement alluded to in my specification is now keeping time in a church clock in the neighbourhood. I shall have another escapement of the same sort finished in the course of next week, which is belonging to a clock I am making for Tideswell Church, Derbyshire. I very much wish the Astronomer Royal would come to Derby to see it, for it is too ponderous an article to be moved and fixed up to show its qualities, or I would bring it to him. I shall feel very proud of the honour at the same time to show him my works, and the manner in which I get up and finish my clocks. The escapement I have alluded to is the very best for large turret clocks that I know of in all my many years' experience. There is one of the same escapements in All Saints Church clock, Derby, made by my late great-uncle, John Whitehurst, F.R.S. The clock was made by him, A. D. 1745, and the clock is now going to time most admirably. I have made a number of large turret clocks with the same escapement, and they invariably keep excellent time.

Note 4.—The remontoire construction alluded to I do not know; I therefore beg the Astronomer Royal will be so kind as to give me instructions how it is to be applied.

Notes 5 and 6.—These particular plans I must also beg of the Astronomer Royal's kindness to give me his instructions.

Note 7.—I shall be most glad to make the clock to strike the four quarters before the full hour. I merely gave my opinion upon this matter in my tender.

I shall be happy to wait upon you or the Astronomer Royal at any time, to give you any further information in my power for the satisfaction of Her Majesty's Commissioners of Woods; and allow me to add, I shall feel it a very great honour to make the clock for them, and they may depend upon my devoted attention to their service.

I have, &c.,

(Signed) *John Whitehurst.*

1847, January 4. No. 28.

A. Milne, Esq., to Mr. *Vulliamy.*

Sir, Office of Woods, &c., January 4, 1847.

WITH further reference to the communications which have been made to you by this Board relative to your plans and specifications, &c., for the great clock at the New Houses of Parliament, I have to acquaint you, that as Mr. Dent purposes, in addition to the plans, &c., which he has delivered, to submit also a model of the clock in card-board to quarter full size, the Board will be willing to receive a similar scale model from you, should you be desirous of submitting one.

I am, &c.,

(Signed) *A. Milne.*

1847, January 5. No. 29.

Mr. *Vulliamy* to *A. Milne*, Esq.

Sir, Pall Mall, January 5, 1847.

I BEG to acknowledge the receipt of your letter of the 4th instant, $\frac{5}{1\cdot1\cdot47}$, requesting to be informed whether I will furnish a model in card-board for the clock at the New Palace at Westminster, as I propose it should be made.

I am on the present, as on all former occasions, anxious to consult such of my friends as I consider capable of giving me the best advice on the subject. This I will do with as little delay as possible, and then answer your letter.

I am, &c.,

(Signed) *B. L. Vulliamy.*

1847, January 13. No. 30.

Mr. *Vulliamy* to *A. Milne*, Esq.

Sir, Pall Mall, January 13, 1847.

IN reply to your letter of the 4th instant, I beg leave to state what appear to me to be valid objections to Mr. Dent's proposal to submit a card-board model of the clock for the New Palace at Westminster.

Such a model made (¼) one quarter size, as stated in your letter, would be 4 feet 4 ins. long by 1 foot 5 ins. wide, and 1 foot 11 ins. high; the size in fact of a small turret clock. Made of card-board, the superficial appearance only of the different pieces would be shown, without any regard to their thickness, and unless thickness as well as superficies were shown, the model would convey but a very indifferent idea of the machine. I do not believe it to be practicable to make a model of this size entirely of card-board; but if it were, it would (judging by the cost of card-board models of buildings) be enormously expensive.

The drawings and specifications which I have had the honour of submitting to the Office of Woods have been made with infinite care and labour, and very considerable expense; and, in my humble opinion, they exhibit the construction of the proposed clock much more closely than could be done by anything less than a working model, which would in fact be a perfect clock one-fourth of the size of that which I have contemplated; and the expense of a card-board model would go far to pay for such a clock, which would be a permanently useful and valuable machine.

It has not been my intention, in my scheme for a clock, to propose such a machine as would go best in a glass case in a nearly equal temperature, but such a one as would be best adapted to the purpose for which this clock is required, and to the situation in which it will be placed. What it would be like is better shown by the Government clocks of my making in and near London than by any model that can be made.

I am now making a quarter clock to show the time upon four faces, for Mr. Peto, which will be but little larger than a model corresponding with Mr. Dent's projected (¼) quarter size model, and I am purposely making it as like the clock which I planned for the Houses of Parliament as it is practicable to make a small clock like a very large one. It will give me very great pleasure to show it to you, and any gentlemen you may wish should see this clock as soon as it is finished.

There are few things more deceptive than models of machinery, as is shown by the numerous inventions which have promised well in the models, and proved utter failures in practice. Of this very many examples might be cited.

Reverting to the nomination of a single referee in a matter of so much importance, permit me to notice that there have at different periods been references made by Government analogous to the present, so far as regards the expenditure of the public money, in matters connected with the merits of horological inventions, namely, in the cases of Harrison, Mudge, Arnold, and Earnshaw,* as is shown by the Journals of the House of Commons, other documents, and sundry publications; but the committees of reference have always consisted of several persons, noblemen, gentlemen, and practical men, the Astronomer Royal in virtue of his office being one.

I enclose a testimonial regarding one of the Government clocks, printed nearly 24 years ago. The anticipations there expressed have been fully realized.

I am, &c.,

(Signed) *B. L. Vulliamy.*

Sir, London, April 14, 1823.

WE have much pleasure in offering you our united testimonial of the great superiority of the large turret clock, which you have submitted to our examination, and which, you informed us, was originally made for the Earl of Lonsdale's seat in Westmoreland. We consider the principle of its construction, and the arrangement you have made for supporting a much heavier pendulum than has been heretofore used, very ingenious, and highly creditable to your professional ability; and the accuracy of the workmanship throughout is such as, we believe, has not been equalled in any clock of similar magnitude. From these essential advantages, we have no doubt you will obtain a precision in the division of time, and a durability of action, which will fully compensate the labour and attention you have bestowed upon this beautiful specimen of mechanical contrivance and execution.

We remain, &c.

(Signed) *M. C. Brunel, F.R.S.* *Thomas Hoblyn.*
Bryan Donkin. *John Pond.*
Joshua Field. *William Congreve.*
Timothy Bramah.

To B. L. Vulliamy,
Clockmaker to the King, Pall Mall.

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* See Appendix No. 5.

1847, February 15. No. 31.

A. Milne, Esq., to Mr. *Vulliamy.*

Sir, Office of Woods, &c., February 15, 1847.

ADVERTING to the communication made to you, through Mr. Barry, in the month of July last, transmitting copy of the general conditions drawn up by the Astronomer Royal to be observed by the maker of the great clock required for the New Houses of Parliament, I have, on behalf of the Commissioners of Her Majesty's Woods, &c., to remit to you copy of further and final conditions, dated the 11th instant, which the Astronomer Royal considers necessary to be observed; and as he also considers that the new condition (No. 16) will cause an increase of expense, the Board have enlarged the time for receiving final tenders, and the particulars required, until Monday, the 15th of March next.

I am, &c.,
(Signed) *A. Milne.*

Royal Observatory, Greenwich,
Sir, February 11, 1847.

IN the interviews which I have had with Mr. Dent and Mr. Whitehurst, I find that it is necessary to impress upon them, a little more strongly than they have yet felt, the necessity of complying strictly with some of my conditions for the clock for the New Palace at Westminster.

And the result of my communication with Mr. Wheatstone is, that I am convinced that it is most desirable that advantage should be taken of the construction of this powerful clock for regulating all the clocks in the Houses of Parliament, Committee-rooms, lobbies, &c.

And generally the business is in such a state that a time may now be fixed for closing the negotiations.

I therefore submit to you a draft of a circular which I would propose to send directly from the Office of Woods and Works, and under the authority of the Commissioners, to Messrs. Dent, Vulliamy, and Whitehurst. As regards myself, the time named is a matter of perfect indifference, and I beg leave to call your attention to it as the point on which the decision of the Commissioners is principally required.

I am, &c.,
(Signed) *G. B. Airy.*

The attention of those Gentlemen who have offered Tenders for the construction of the Clock for the New Palace at Westminster is requested to the following Remarks:—

It is indispensable that the following conditions (which were sent in the first communication from the Office of Woods and Works) be fully complied with.

No. 3. The wheels are to be so arranged that any one can be taken out without disturbing the others.

No. 7. The train of wheels is to have a remontoir action, &c.

No. 8. The clock is to have a going barrel.

No. 11. The striking machinery is to be so arranged that the first blow for each hour shall be accurate to a second of time.

These conditions are particularly urged, because the constructions to which they refer being not in extensive use in this country, they may, in the adaptation of ordinary plans to the new clock, be inadvertently passed over. But it is not intended that the stringency of the other conditions shall be in any degree relaxed.

The following condition is to be taken as here explained:—

No. 12. The striking detent or striking hammer for the hours is to be so arranged that at every blow it will break contact with a powerful magnet, mounted on the principle recommended by Mr. Wheatstone for the formation of a magneto-electric current.

And the following condition is new:—

No. 16. The hour wheel is to carry a ratchet-shape wheel or a succession of cams, which will break contact with a powerful magnet, on the principle recommended by Mr. Wheatstone, at least as often as once in a minute, for the purpose of producing a magneto-electric current, which will regulate other clocks in the New Palace.

As the new condition No. 16, requiring increased power in the maintaining force, will probably make it necessary that the barrel of the first wheel of the going part be somewhat increased, so as to take full advantage of the depth allowed for the fall of weights, it is requested that (if it is judged necessary) sketches may be sent to the Office of Woods and Works, showing generally the alteration which this will make in the plans already sent.

And as the new condition will slightly increase the expense, it is requested that final tenders, applying to the last plans sent to the Office of Woods and Works, or to the Astronomer Royal, and embracing every part of the machinery (stating distinctly whether the iron or stone supports, the clock hands, and the clock faces are included), be sent to the Office of Woods and Works on or before Monday, 15th March.

February 11, 1847. (Signed) *G. B. Airy.*

Remarks upon a new condition (16) *forwarded to Mr. Milne by Mr. Airy, 11th Feb.*, 1847.

It is presumed that what is here meant by Mr. Airy and Professor Wheatstone, is to employ the great clock as an agent to show the time upon an unlimited number of clock-faces in various parts of the building, by means of an electro-magnetic current. That the surplus power of the clock will be sufficient to accomplish this cannot be doubted for a moment; but not so its uniform practicability. The scheme has been tried, and has partially succeeded in some instances, and failed in others; but in the supposed case of employing a clock, which shows the time externally, as the motive power, an objection presents itself which it is quite beyond the reach of art to overcome. All public clocks are, more or less, liable to be stopped by a snow-storm. Probably there is not a clock in the metropolis which has not been stopped in this manner; and the time required to clear away the snow, to free the hands, and to set the clock going again, depends entirely upon the weather and local circumstances. The proposed clock, at the immense height at which it will be placed from the ground, with four faces very much larger, and hands longer, than those of any other clock in the kingdom,* and in such close proximity to the Thames, in a most exposed situation, and subject to every wind that blows, will be very liable to be stopped from this cause. Now, when the principal clock is stopped, it follows that all the others are stopped also. Hence very great public inconvenience would arise; for the forms of both Houses of Parliament render it imperative that the hour of four should be distinctly noticed, and also the conclusion of one day and the commencement of the next. But it is impossible to say how often the cause of stoppage adverted to may occur, or how long it may operate when it does occur. It is obvious that the action of the principal clock may be suspended by this cause, and it is equally evident that the same effect must follow upon all the dials dependent upon the large clock. Besides this natural cause, which is inevitable and uncontrollable, there are many accidents of common occurrence which may produce the same effect and create the same inconvenience. It is a great mistake to designate as clocks dials upon which time is shown in this manner; they possess neither pendulum nor maintaining power; they are simply dial plates and hands, with a portion of the wheels of an ordinary clock, and the work required to make the hands, which move by starts, advance at given equal intervals of time. It is also a great mistake to suppose that these machines, with the necessary apparatus, are made at a small expense: experience has shown the contrary to be the case. It may be observed that all attempts to make clocks strike by this process have proved utter failures: such contrivances are, therefore, wholly inapplicable to situations where striking clocks are required.

1847, March 5. No. 32.

Mr. *Whitehurst* to *A. Milne*, Esq.

Sir, Derby, March 5, 1847.

I HAVE the honour to acknowledge the receipt of your letter 15th February, 1847, with the further remarks of the Astronomer Royal relative to the new clock for the New Houses of Parliament; and I beg to say, I have herewith enclosed my plan of a separate piece of clockwork to be appended to the great clock for the new Houses of Parliament, to break contact with a powerful magnet once every minute, to regulate the other clocks in the New Palace on the principle recommended by Mr. Wheatstone, and which plan I think will meet with the approval of the Astronomer Royal, as it can be extended to any number of different magnets without interfering much with the clock keeping time.

The Astronomer Royal has been to Derby to see my works and the new clock which I am completing for Tideswell Church; he particularly requested me to see the clock at the Royal Exchange, that I may observe how those parts which he is desirous of having adopted in the great clock for the New Houses of Parliament are constructed; he has very kindly obtained me permission from the Gresham Committee to inspect the clock; I therefore intend being in London on Monday morning next, the 8th instant, for that purpose, when I will do myself the honour to wait upon you, and then upon the Astronomer Royal at Greenwich, to confer with him and receive his further instructions.

I have, &c.,
(Signed) *John Whitehurst.*

Office of Woods, &c., July 15, 1847.

Morpeth,
A. Milne,
Charles Gore.
} Commissioners of Her Majesty's Woods, Forests, Land Revenues, Works, and Buildings.

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* See Appendix No. 6.

1847, March 15. No. 33.

Mr. *Vulliamy* to the *Commissioners of Woods and Forests.*

My Lord and Gentlemen, Pall Mall, March 15, 1847.

I BEG to acknowledge the receipt of your letter of the 15th February, and its enclosure, dated the 11th of the same month, signed by Mr. Airy.

The Astronomer Royal has officially reported to the Royal Exchange and Gresham Trusts Committee the clock at the Royal Exchange to be, in his opinion, the "*best in the world.*" Now, Mr. Airy himself very recently told me he had not seen the public clocks at Paris, which are the most deserving of notice of any I am acquainted with.

Subsequently to my letter to Mr. Barry, dated 22nd July, 1846, wherein I declined to enter into the competition for making the clock for the New Palace at Westminster, a copy of a letter from the Astronomer Royal to the maker of the clock at the Royal Exchange, together with some other papers connected therewith, have been put into my hands. This letter can lead to no other conclusion than that expressed in my answer to Mr. Barry before referred to. The maker of the clock at the Royal Exchange, in a memorial to the Office of Woods, dated the 14th December, 1845, in which he solicits to be employed to make the clock for the New Palace at Westminster, proposes the Astronomer Royal as the referee, under whom he shall execute the work, and forwards with his memorial a copy of the letter before referred to, dated 22nd July, 1845, from Mr. Airy, addressed to himself, in which that gentleman, after repeating the assertion that the clock at the Royal Exchange "*is the best in the world,*" concludes by saying, if he should be consulted, "*I shall state, without hesitation, that I consider you as the most proper person to be intrusted with the construction of another clock of similar pretensions.*" As this letter is a most important document, I have added a copy of it in the form of a postscript to this communication.

It appears from the above statement, first, that the maker of the Royal Exchange clock proposes the Astronomer Royal as his referee; second, that the Astronomer Royal has prejudged the question, and decided that the maker of that clock is the only fit person to be employed on the present occasion. These circumstances fully justify my declining to enter into a competition with the maker of the Royal Exchange clock in a case in which the Astronomer Royal is to be the sole referee.

The experience of 30 years constantly employed in the improvement of public clocks, as well in principle as construction (during which time I have examined some of the most celebrated machines of the kind on the Continent as well as in England), has led me to the conclusion that the plan laid down by the Astronomer Royal will not answer his expectations. The maker of the Royal Exchange clock has had but three or four years' experience in the construction of public clocks, and the performance of his principal work has not, in reference either to the going or striking, been what was expected after the eulogium that had been passed upon it by the Astronomer Royal.

I still adhere to my objection (stated in my letter of the 22nd July, 1846) to certain conditions specified by the Astronomer Royal, with reference both to the material and execution of the clock. But I beg to be understood not to make any objection whatever to that part of his last specification which refers to the application of magnetic mechanism; what he requires may, I apprehend, be done without difficulty, or without in any way deranging the general plan of the clock as laid down in my plan and specification. Also, I repeat that I am willing to compete, and furnish an estimate for the clock, provided the referees who are to decide on the merits of the different plans be chosen in the same manner as has been done on similar previous occasions, and that the determination be not left to any single individual.

I take this opportunity to forward you a statement of my labours in the improvement of public clocks, from which it will be seen that 30 years of my life have been devoted to that object; I may add, that all the more recent improvements (including some of the conditions imposed by the Astronomer Royal in his specifications for the Royal Exchange clock, and the clock required for the New Palace at Westminster,) originated with me, and have been in use for many years past; and that I have constructed many clocks of considerable importance, as well for Government as for sundry public buildings, to which reference may be made by all who are interested in the question. It is on these grounds that I put forward my claims to be employed on the present occasion.

I have, &c.,
(Signed) *B. L. Vulliamy.*

P.S.

"Sir, "Royal Observatory, Greenwich, July 22, 1845.

"IN the event of my being consulted by the Commissioners of Woods and Forests in regard to the erection of a first-rate clock in the New Houses of Parliament, I shall state, without hesitation, that I believe the clock which you have constructed for the Royal Exchange to be the best in the world as regards accuracy of going and striking, and that I consider you the most proper person to be intrusted with the construction of another clock of similar pretensions.

"I have, &c.,
"Mr. E. J. Dent. (Signed) *G. B. Airy.*"

STATEMENT of the Grounds on which B. L. VULLIAMY claims to be Employed to make the GREAT CLOCK for the NEW PALACE at WESTMINSTER.

March 13, 1847.

Since 1810 devoted particular attention to improving the construction of public clocks.

I do not lay any very great stress on the circumstance of my having been regularly appointed clockmaker to their Majesties King George the Third, King George the Fourth, King William the Fourth, and also to Her present

Majesty, and constantly employed as such, though this circumstance is certainly deserving of consideration; but on the fact of my having for many years, (since about the year 1810,) devoted particular attention to the construction and improvement of public clocks. To this I was led from having the care of all the clocks belonging to the Crown.

From that period to the present time I have constantly had in view the improvement of this branch of the art; and that portion of time which the most eminent of my professional brethren have spent in the improvement of marine chronometers, I have devoted to the same end in reference to public clocks.

Appointed clockmaker to the Ordnance in 1826.

On the death of the late Mr. Thwaites in 1826, the Duke of Wellington appointed me clockmaker to the Honourable Board of Ordnance. This appointment brought a very considerable number of public clocks under my care, most of which afforded evident proof of the little progress that had been made in their construction and manufacture; indeed, in some respects, the art might be said to have retrograded. I was induced still further to consider the possibility of materially improving them, both in the principle on which they were made, and also in the execution of the work.

Visited Paris in 1825 to see the public clocks.

In 1825 I went to Paris to see the public clocks in that city, particularly that at the Hotel de Ville, of which common report spoke very highly, and with justice: it is a 30-hour clock, made by Lepante in 1781, and cost, including the two dials, three bells, and fixings, 90,000 francs (3000*l.*)

Clock made for Norwood Church in 1827.

Surveyed and reported upon by Sir John Jones.

The first clock I made after my return was in 1827, for the New Church at Norwood. In this I adopted an entirely new mode of construction, which I have since followed with great success. By direction of the Honourable Board of Ordnance, it was surveyed by the late Sir John Jones, Commanding Royal Engineer at Woolwich, a portion of whose report thereon I give in the annexed note; * but I cannot find terms sufficiently strong to express the gratification I feel at being able to record such an opinion coming from an individual enjoying so high a reputation as that distinguished officer.

Some of the advantages attendant upon the new construction.

Some of the peculiar advantages of the new mode of construction of which I have just spoken may be briefly described as follows:—

Upon the old plan all the parts are mounted in one frame.

In a turret clock, made upon the common or old construction, the wheels, and in fact all parts of the work, as well relating to the going as to the striking part or parts,† are mounted in one frame. This frame is composed of various pieces in the form of flat bars and round pillars, which are connected together by screws and nuts, and generally so arranged that the pivots of each train of wheels act in two opposite bars; consequently, when

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* *Note.*

Sir, Office of Ordnance, October 6, 1828.

In reply to your letter of the 4th instant, I am directed by the Board to transmit to you an extract from the Report made by Colonel Jones, Commanding Royal Engineer, at Woolwich, respecting the clock made by you for Norwood Church.

I am, &c.,

To Mr. Vulliamy. (Signed) *R. Byham.*

An Extract from a Letter, dated the 4th August, 1828, from Colonel Jones, Commanding Royal Engineer at Woolwich, to the Secretary of the Honourable Board of Ordnance, reporting on a Clock fixed up in Norwood Church by Mr. Vulliamy.

In obedience to your letter of the 28th of July, I have been to Norwood, and have minutely inspected in detail the works, &c. made and fixed up in the church in that place by Mr. Vulliamy. I beg leave to report that it appears to me superior to any turret clock I have seen, in the following points:—

1st. In simplicity of construction, there being fewer wheels and pinions, both in the going and striking parts, than in an ordinary clock; and those two movements being perfectly distinct, and only acting together through the medium of the discharging piece, any accident to the one may be repaired without deranging the other. Indeed, this latter advantage may be said to extend through every detail of the machinery; for the holes of the pivots, in which the wheels work, being fixed by screws, the simple removal of the bosses enables a single wheel or piece to be taken out and repaired or cleaned, without taking to pieces the remainder of the works. This construction also gives great facility for keeping the machinery oiled.

2nd. In durability.—The wheels and pinions are made of hard gun metal and steel, which latter, besides being of long duration, have the advantage over the usual iron case-hardened pinions, wearing equal y, and not into angular points, which is found to destroy the wheels most rapidly. This substitution of hard gun metal and steel for yellow brass and case-hardened iron, appeared to be general throughout the acting parts of the machine, giving more strength to each.

3rd. In regularity of keeping time.—The escapement is a dead escapement, which has the least possible loss of power from drop; and is so well contrived that it instantly caught my attention. In this clock it maintains in motion a pendulum weighing 150 lbs.; which, being far heavier than the pendulum of an ordinary clock of the same size, cannot fail to make it go accurately.

The barrel cylinders, round which the lines of the weights are coiled, are of iron.

The workmanship of every part is of excellent quality, and very far superior to that of the clocks at Woolwich.

Conclusion.—From the above it seems almost certain that a clock of this construction, besides showing the time more accurately, must last much longer, and be more rarely out of repair than an ordinary clock; and further, from its simplicity, it may be looked after and kept in order by a very ordinary mechanic.

† A clock that strikes the hours has one striking part; if the hours and quarters, two striking parts.

When large and heavy, very troublesome to take to pieces and put together.
Also attended with risk of injuring the work.

either of these bars is for any purpose removed, the entire train of wheels becomes loose and disengaged; so that when the clock is large, and the parts heavy, it requires the help of two or three assistants to prevent them from falling, which renders the operation of taking the clock to pieces attended with much trouble, to say nothing of the risk of bending or breaking the pivots or of damaging the wheels. To avoid such accidents, the pivots are generally made larger than would otherwise be necessary, and this greatly increases the friction. Now, however well this frame-work may be executed (and if made of sufficient strength, and well executed, it becomes very expensive), still it is far from possessing the requisite solidity for a machine to measure time, on account of its being so much affected by the vibratory motion caused by the striking part or parts.

If well executed, very expensive.

In the new construction, the going and striking parts are entirely detached from each other.
One piece can be removed without disturbing another.

In the new construction, the going and striking part, or parts, are perfectly detached from each other; and the wheel-work, &c., of each part is supported by a separate, solid, and entire bed of cast iron, instead of a frame composed of pieces as formerly. The arrangement of the several parts is such that any one piece can, if required, be removed and restored to its place without disturbing another, and the whole of the clock is perfectly solid, and without shake or motion.

The jar attendant upon the striking confined to the striking part.

The jar, and consequent tremulous action, resulting from the fall of the hammer-tail or tails, according as the clock strikes hours only, or hours and quarters, which in the common turret clock is communicated to the whole machine, is, from the construction of this clock, entirely confined to the striking parts.

The mode of communication from the clock to the dial works very simple.

The construction of the work for communicating the motion from the clock to the hand is entirely different from that usually employed in turret clocks. It is securely attached to the cast-iron bed of the going part, is particularly simple, little liable to be out of order, and the connexion between the clock and the dial works, that carry the hands, is made by a straight iron rod, leading direct from the clock to each dial work. The bad arrangement of this part of the work is a very common cause of failure in the generality of large clocks.

The construction offers peculiar advantage for cleaning, &c.

The construction of a turret clock which I have adopted offers peculiar facilities for cleaning and oiling the works, which the common construction does not possess, and it can in consequence be kept clean and in order with less trouble, and at much less expense, than a clock made in the ordinary mode.

The first clock entirely made upon this construction was that put up in the tower of Norwood Church, A.D. 1827; but I have made several clocks upon the same principle since, and with equal success, but will content myself with referring more particularly to those I made for Windsor Castle, and for the new Victualling Office at Cremille, near Plymouth, both of which are eight-day clocks, and strike the quarters as well as the hours. The former is very large, the great wheels of the striking parts being 24 inches in diameter, and the hour is struck upon a bell of 32 cwt.

The clocks made for Windsor Castle and the new Victualling Office at Cremille, near Plymouth, are made on this construction.

The clock-room, Windsor Castle, particularly easy of access, well lighted, and ventilated.

The clock-room at Windsor Castle is the easiest of access, the best lighted and ventilated, and in all respects the best adapted to the purpose for which it is intended of any that I am acquainted with; but from local circumstances, which the skill of the architect, Sir Jeffrey Wyattville, could not overcome, the construction of this clock was attended with much difficulty. The fall for the weights is exceedingly small, and the dial (for the time is shown only on one face) is placed considerably below the clock; the pendulum also is unavoidably very short, and the bells are placed at a considerable distance behind the clock; all which circumstances are more or less prejudicial to its performance. Nevertheless, the accuracy with which this clock has measured time has been everything that could be desired.

Clock at Cremille made under the direction of Sir John Rennie.
Shows the time on four faces.
The situation particularly exposed.

That at the Victualling Office, made under the immediate direction of Sir John Rennie, though somewhat limited for space, is in every respect a very perfect piece of work. The time is shown upon four very large faces, and there are probably few clocks to be found in so exposed a situation. This clock may be said to face the Atlantic, and to brave the storms of the Western Ocean. It stands at the head of Plymouth Sound; and a straight line drawn from the clock across the centre of the breakwater would cross the ocean, and only terminate on the coast of America. All persons conversant with the south coast of this island are aware of the violence of the gales of wind which occasionally visit Plymouth Harbour. Though much confined for room, the general arrangements of this clock are everything that I could wish; it has a two-seconds pendulum, with a bob weighing 258 lbs., yet the weight of the maintaining power, calculated with a single line, is only 26½ lbs. The scape wheel of the clock carries a seconds hand

The arrangements very good.
Has a two-seconds pendulum.
The bob weighs 258 lbs.
The clock shows seconds inter-

nally, and the arc of vibration of the pendulum is indicated.

to show time within, and a degree plate is employed to indicate the arc of vibration of the pendulum; consequently there is not any difficulty in determining exactly the deviations of the clock from mean time. The mode employed for communicating the motion from the clock to the hands is simple and convenient, and has not on any occasion got out of order. This clock, notwithstanding its exposed situation, has kept time so correctly as to become the standard for regulating time in all the Government establishments at Plymouth, Devonport, Stonehouse, and all other public clocks in the neighbourhood.

Is the standard clock for the neighbourhood.

Clock at the New Post Office.

I will briefly notice the clock at the New Post Office, because it is considered a very beautiful specimen of the art on a small scale, on account of the weight of the pendulum bob, which is 448 lbs., requiring a maintaining power of only 33 lbs. to cause it to vibrate 2′ 20″ on each side of zero; this weight, considering that it is for an eight-day clock, which is much incumbered with rod-work, and labouring under manifold disadvantages consequent upon its ill-contrived situation, is, in reference to the weight of the bob, an extremely small motive power.

Weight of bob 448 lbs.

The proposed clock to resemble in part the clocks at Norwood, Windsor Castle, Cremille, and the Post Office.

The clock I have proposed as most fitting for the New Palace at Westminster would be, in many respects, similar to the clocks made for Norwood, Windsor Castle, and Plymouth, but of necessity larger and stronger in proportion to what it is required to accomplish.

The only inconvenience of this construction is the length of the clock, which, in some situations, renders it inapplicable.

There are few advantages to be obtained without some concomitant disadvantage, or at least some inconveniences. The only inconvenience, however, that I am aware of, resulting from the new construction for public clocks, is the increased length of the machine, caused by the parts being placed side by side, instead of one over the other, as in those made on the old plan. This circumstance sometimes proves an obstacle, which, from local circumstances connected with the building, cannot be overcome. It was for this reason that I was compelled to employ the old plan in the two very large clocks I made for the cathedrals at Oxford and Calcutta, the latter of which struck the quarters upon four bells.

Claim of the writer to have originated the various recent improvements in public clocks.

The employment of a 2″ pendulum.

Hands to show seconds within.

Degree plate, to ascertain the arc of vibration of the pendulum.

The wooden rod. Short suspension spring. A very heavy bob.

I may, I think, very fairly lay claim to be the originator of the various improvements that have taken place within these few years in public clocks; for instance, I was the first in this country to employ a two seconds pendulum (the clock at the Hotel de Ville at Paris is indeed the only clock on the Continent that I ever saw with one), or who applied a hand to indicate seconds, or a degree plate, by which to ascertain the arc of vibration of the pendulum, and, with few exceptions, to employ for a pendulum a wooden rod, a short suspension spring, and a very heavy bob. Previously to this, the pendulum rods were almost invariably made of iron, with very long springs and light bobs. The only instance, in fact, that I am acquainted with of a wooden pendulum rod applied to an old clock was to that of the Horse Guards, which I happen to know was made at the suggestion of my father many years since, and which I replaced in 1816 by a two-seconds pendulum with a teak rod and bob weighing 190 lbs.*

Horse Guards clock, applied a 2″ pendulum bob weighing 190 lbs.

Gun metal substituted for yellow brass.

Its use recommended by Sir John Jones.

I was likewise the first to employ gun metal in the place of yellow brass for the pivot holes, wheels, and other parts commonly made of brass.

The employment of gun metal, as a substitute for brass, was recommended to me by Sir John Jones, to whom I am indebted for many valuable suggestions; and it certainly is a very great improvement.

Public clocks in Flanders not deserving any particular notice. Went to see the Exposition at Paris in 1844.

I have examined some public clocks in Flanders, but did not see any deserving notice. In 1844 I went to Paris, in order to be present at the Exposition de l'Industrie Frangaise. There I saw a number of public clocks of various sizes and descriptions. In those of a superior quality the wheels were made of yellow brass, and in the inferior, the wheels of the striking train were of cast iron, and the going train only of brass; but in no instance that fell under my notice, was gun metal employed. Most of the clocks of a superior description were furnished with a contrivance called a remontoire. This mode of construction, most inviting in appearance, but substantially bad, has long been the idol of the continental artists, who devised various modes of applying it to their marine chronometers; but in this country it has found less favour, its fallacy having been long since detected.

The wheels made of yellow brass and cast iron.

Gun metal not employed by the French.

Remontoire applied in many cases, but objectionable.

Mr. Mudge employed a remontoire in his chronometers.

Mr. Mudge was, I believe, the only English maker who employed it; and his chronometers, though executed with infinite care, and at very great

* I have preserved the old pendulum, which, incredible as it may appear, is furnished, as well as the pendulums I have taken from the Ordnance clocks, with fans. I have also collected a number of escapements taken from various clocks, some of which, though extremely curious, give, by their wear, incontrovertible evidence of imperfection in their construction.

Arnold's and Earnshaw's construction are of much greater simplicity.

The French clockmakers apply the gridiron pendulums to their public clocks.

Did not in a single instance notice either a seconds hand or a degree plate to be employed by the French.

Great weight of the pendulum rod objectionable.

The public clocks in Belgium wound every day; show the time by only one hand; and do not strike upon particularly large bells.

Their performance very indifferent.

My capability to execute the work. Alleged that I do not possess a special manufactory; consequently that the work cannot be well done. It has been intimated that only one individual possesses the necessary capabilities to construct clocks of a superior description.

Refutation.

Was indebted to the late Timothy and Francis Bramah for permission to employ their manufactory as my own.

Continued to enjoy the same advantages per favour of Mr. Robinson, their successor.

Make all my drawings myself.

The manufactory at Pimlico affords facilities superior to those possessed by any clockmaker in London.

expense, were found not to perform so well as Arnold's and Earnshaw's, which, though not better executed, were much more simple in construction, and consequently less expensive, as well as less liable to derangement. This remark applies equally to clocks, to the performance of which a remontoire is as objectionable as to chronometers.

No expense is spared in the pendulum of French clocks of a superior class, which are all what are termed gridiron pendulums, of various constructions, varying from five to nine bars, and in length from about five to seven or eight feet; consequently the clocks cannot indicate seconds in the ordinary mode; indeed I did not notice a single clock of this description to which a seconds hand or index, or a degree plate, to indicate the arc of vibration of the pendulum, was supplied. The execution of these pendulums certainly is very beautiful; but the great weight of the rod in reference to the bob is a very serious error in principle, and, in my opinion, more than counterbalances any advantages they may be thought to possess.

I will here notice that the clocks in Belgium that I saw, some of which show time upon very large skeleton dials, have only one hand, which makes a revolution in 12 hours, and they were wound every day; they likewise strike upon bells comparatively small. These circumstances very much diminish the difficulties attendant upon making a clock of this description. Moreover, the performance of most of the Flemish clocks is such as would not be tolerated in the situation for which the clock for the New Palace is required.

It has been repeatedly intimated, in the form of paragraphs in the daily papers and periodical publications, that only one individual in the profession possesses the necessary capabilities to construct public clocks of a superior description; and also, that the greater number of clockmakers do not possess any special manufactory for large clocks, and that consequently work cannot be so well done, or on such reasonable terms, as by an individual who has such a manufactory. Further, that the tools employed by the generality of clockmakers are of a very inferior description, and ill qualified to execute work of a very superior character.

The first part of this statement I feel called upon to notice, which I shall, however, do very briefly. I was indebted to the liberality of my much-regretted friends, Mr. Timothy and Mr. Francis Bramah, for the permission to employ their foreman and manufactory precisely as though they were my own. This I have done for the last 25 years; and through the kindness of Mr. Robinson, their successor, this convenience has been continued to be afforded me in its fullest extent. All my work, therefore, both iron and gun metal, has been cast at their works at Pimlico, and all my large work manufactured there; the whole under my immediate superintendence, by going on the premises whenever I chose, without let or hindrance, and giving my instructions personally to the foreman, without the intervention of any third person. All my working drawings have been made by myself; and in order to insure perfection in casting, my patterns (of which I possess a large collection) are all made of mahogany, under my immediate direction. It is scarcely necessary to add, that the manufactory at Pimlico affords facilities for executing work, large and small, in the shape of lathes, planing machines, and tools of every description, as well as a wheel-cutting engine, that will cut the teeth in a wheel of seven feet diameter in a manner far superior to those afforded by any clockmaker's establishment in London. I am quite sure that I am much within compass when I say that it would require a capital of not less than 10,000*l.* to establish a manufactory for making public clocks, that would contain under one roof all the conveniences afforded by Mr. Robinson's manufactory.

(Signed) *B. L. Vulliamy.*

To the Commissioners of Her Majesty's Woods, &c.

1847, March 15.

No. 34.

Mr. *Dent* to *T. W. Philipps*, Esq.

Sir,

33, Cockspur-street, March 15, 1847.

I BEG leave to inform you, for the information of Her Majesty's Commissioners of Woods and Forests and the Astronomer Royal, that in reply to the communication received by me, dated February 15, 1846, enclosing a copy from the Astronomer Royal, requesting that the following conditions, stated in the original circular at Nos. 3, 7, 8, 11, and 12, should, from their not being in general use, become omitted in the clock for the New Palace at Westminster, I respectfully state that all of them shall be strictly carried out in my plans.

The new conditions stated at No. 16 having reference to the electro-magnetic apparatus, and not having a practical knowledge of such a subject, I found it necessary to communicate with the Astronomer Royal; and, having received his instructions, I forward a plan for the letting-off of other clocks by the electro-magnetic

current, agreeably, as I suppose, to his views. As there is a trifling difference in the mechanical arrangements of the magnets as seen at Nos. 2 and 3, perhaps the Astronomer Royal will decide if either be approved.

I request also to forward a further statement as regards the first estimate, and also another estimate to complete the entire work. The main walls are now to be carried into the room, and the clock frame will require to be lengthened, so as to admit of the clock being securely fixed on the walls, as seen in the accompanying drawing (A). The clock faces are of stone, and part of the tower. The numerals, &c., I have proposed in the former estimate to gild. The hands complete are also to be supplied at my cost.

I have, &c.,

(Signed) *E. J. Dent.*

ESTIMATE for making and erecting the LARGE CLOCK for the NEW PALACE at WESTMINSTER.

I AGREE to increase the size of the wheels, as well as the clock frame, agreeably to the accompanying drawing, and to add all the necessary work for the electro-magnetic apparatus, including a powerful magnet; and I further propose to render the clock complete in all respects for the sum of 1600*l.*

This sum not to include any mason's, bricklayer's, or carpenter's work; and that I be allowed the use of the scaffolding, supposing I cause no delay.

The payment not to be made until a written certificate is obtained from G. B. Airy, Esq., Astronomer Royal, that the work is completed to his satisfaction.

33, Cockspur-street.
March 15, 1847.

(Signed) *E. J. Dent.*

1847, March 15. No. 34.*

Explanation of Drawing A.

THE disposition of the hour and quarter train of wheels, and the striking parts, are altered from any of the former plans previously given.

The striking train of wheels and the striking parts are now in front, and while it will be more readily got at, it will also add much to the general good appearance of the mechanism. On viewing the clock endways the striking parts will be seen to occupy the front, and the going part standing alone at the back, which is not the case in the Royal Exchange clock.

As the whole of the large wheels will run in holes on the lower frame, perhaps Mr. Airy will be so kind as to say if he considers the form of the frame which passes from the one wall to the other suitable in figure to carry the weight of the whole, and which, I suppose, will be about 14 hundred weight. The cams of the hours will give a lift of eight inches from the first power, and which is far more than any other clock that I am aware of.

The arrangement for this drawing has nearly occupied all my time since I received the last communication from the Astronomer Royal, forwarded from the Office of Woods and Forests on the 15th February, 1847, No. 1148.

The drawing now sent can only be considered as a sketch; I, therefore, respectfully state that in the event of my having the manufacture of the clock committed to my charge, I will submit the working drawing to the Astronomer Royal previously to the commencement of the manufacture.

The drawing, B, is explained on the paper.

March 15, 1847.

(Signed) *Ed. J. Dent.*

HOUSES of PARLIAMENT LARGE CLOCK.—March 12, 1847.

Calculation for the Fall of Weights and Train of Wheels.

The entire height for the fall of weight is 195 feet, and allowing five feet for length of weight and pulley, gives a clear fall of 190 feet.

Striking Part for the Hours.

Diameter of barrel, 23 inches = 190 feet fall with a pulley.
Diameter of wire rope, 0·3 inches = 19 inches for the length of barrel.
Number of turns for eight days, 63.
Diameter of great wheel, 30 inches; 160 teeth; cams, 20; thickness, 2½ inches.
Number of pinion, 16 leaves.
Diameter of second wheel, 14 inches; 100 teeth; gives one turn for two blows; one inch thick.
Pinion, 20 leaves.
Diameter of bevel wheel, 9 inches; 88 teeth = 22½ turns for one blow; 0·7 inch thick.
Fly pinion, 20 leaves = 11 turns for one blow.

Striking Parts for the Quarters.

Diameter of barrel, 23 inches = 190 feet fall with a pulley.
Diameter of wire rope, 0·3 inch = 19 inches for length of barrel.
Number of turns for seven days and 21 hours = 63.
Diameter of great wheel, 30 inches; 160 teeth; 30 cams; thickness 2½ inches.
Pinion, 16 leaves.
Diameter of second wheel, 14 inches; 108 teeth = one turn for three blows; one inch thick.
Pinion, 18 leaves.
Diameter of bevel wheel, nine inches; 84 teeth = two turns for one blow; 0·7 inches thick.
Fly pinion, 14 leaves = 12 turns for one blow.

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* This is the portion of the paper that was withheld when the first part was given.

Going Part.

Diameter of barrel, 19·5 inches = 99 feet fall with a pulley, and 39 turns for eight days.

Going Train.

Diameter of great wheel, 22 inches; 150 teeth = one turn in five hours.
Pinion, 30 leaves = one turn in one hour.

(Signed) *Ed. J. Dent.*

Mr. Dent, after having generally expressed his intention to strictly adhere to Mr. Airy's instructions, (repeated in his letter of the 11th February, 1847,) specifically notices the 16th, having reference to the electro-magnetic apparatus, and forwards "*a plan for the letting off of other clocks by the electro-magnetic current.*" Mr. Dent's meaning by "*letting off*" is not very well expressed; if his intention be the same as Mr. Airy's, before noticed, of showing the time upon an indefinite number of faces, (and this is the only construction of which it appears to be susceptible,) the objection to that plan has been sufficiently noticed, and need not be repeated. The increase of 100*l.* in the amount of the estimate is to cover the additional expense caused by "*the new condition stated at No.* 16."

This is the paper of which the portion beginning by the "*Explanation of Drawing A.*" was withheld, when the first part of the paper was furnished, and may be considered as a third specification.

1847, March 15. No. 35.

Mr. *Whitehurst* to *A. Milne*, Esq.

Sir, Derby, March 15, 1847.

I HAVE the honour to inform Her Majesty's Commissioners of Woods, &c., that, by the kind assistance of the Astronomer Royal on my visit to him last week, I am now made fully acquainted with the construction particularly required by him in his remarks, 11th February, 1847, for the making and completing the great clock for the New Houses of Parliament.

No. 3. I will arrange the wheels so that any one of them can be taken out without disturbing the others.

No. 7. I will make the train of wheels to have a remontoir action, regulated with a fly.

No. 8. I will make the clock to have a going barrel, upon the principle invented by the Astronomer Royal.

No. 11. I will so arrange the striking machinery, that the first blow for each hour shall be accurate to a second of time.

Nos. 12 and 16. I have constructed a separate piece of clockwork, to be appended to the great clock for the New Houses of Parliament, to break contact with a powerful magnet once every minute, to regulate the other clocks in the New Palace, on the principle recommended by Mr. Wheatstone. This plan I had the honour of explaining to you, and by your request I delivered it to the Astronomer Royal, and I am happy to inform you he approves of the plan. This additional piece of clockwork I will make and complete, ready to receive Mr. Wheatstone's magnets, for the sum of 150*l.* in addition to my former estimate. Neither this, nor my former estimate, includes the joiner's work, mason's work, nor scaffolding, nor smith's work, nor iron nor stone supports, nor the clock dials, which are to be paid for extra.

I beg to say that the Astronomer Royal has imparted to me very valuable information, and has kindly promised to assist me and give me any further instructions I may require at any time. I shall feel great comfort and confidence in making the clock under his immediate directions, for I find him an able mechanic, and well versed in horology; and I beg to express my grateful thanks to yourself and the Astronomer Royal for your great kindness and assistance to me on all occasions.

I beg my humble duty to my Lord Morpeth and Her Majesty's Commissioners of Woods, &c. I shall feel it a great honour to be employed by them to make the great clock for the New Houses of Parliament, and my best exertions shall be devoted to their service.

I have, &c.,
(Signed) *John Whitehurst.*

P.S. When I was in London last week I heard the large bell at Messrs. Mears's foundry, which they have just cast to go to Montreal. It is a most noble bell, and has a majestic sound; it is rather smaller than the great bell intended for the New Houses of Parliament. I was much pleased to hear it.

1847, May 18. No. 36.

G. B. Airy, Esq., to *A. Milne*, Esq.

Sir, Royal Observatory, Greenwich, May 18, 1847.

IN reference to the correspondence which has taken place in regard to the selection of an artist for the construction of the intended great clock for the New Palace at Westminster, I have the honour to state that I have now so far examined into the matter as to feel myself competent to make a general report upon it, indicating some points upon which I can give distinct information, and others upon which I think it desirable that the Commissioners of Woods and Works should decide.

In this report it is my intention to allude only to Mr. E. J. Dent and Mr. J. Whitehurst as competitors. I propose, however, to annex to it a paper, with some remarks on the communications of Mr. B. L. Vulliamy.

1. On the means possessed by Mr. Dent and Mr. Whitehurst for making a clock of very large dimensions.

I have examined the factories of both these makers, and I find the following points of comparison :—

Mr. Dent's factory is the larger; but every part of Mr. Whitehurst's is made available, and is actively used.

Mr. Dent's tools are somewhat superior to Mr. Whitehurst's. He has (I think) larger lathes. He has a planing engine. Mr. Whitehurst has none; neither has he a fixed drill frame.

I do not consider that either of these makers could undertake the manufacture of the large clock without considerable assistance from some engineer's establishment, at the least for the large frame and for the first large wheel in each train. With such assistance either of them is competent (as regards his plant of tools) to undertake it.

2. On the personal abilities of the two makers.

The education of these two makers has been very different.

Mr. Dent has, to a very late time, been simply a clockmaker (on the small scale of astronomical clocks, &c.) and chronometer maker. In the latter capacity he has been compelled to pay the utmost attention to the excellence of fine workmanship, and to secure by all means great accuracy in the results (the chronometers being subjected to the severest examination in the rating at the Royal Observatory). Since he commenced the manufacture of turret clocks, he appears to have entered in an enterprising manner into that business, examining the construction of foreign clocks of celebrity, and making himself acquainted with the literature of this subject. With the literature of chronometer constructions he was previously well acquainted.

Mr. Whitehurst has had no concern (I believe) in work more delicate than that of first-rate house clocks, but he has had very considerable experience in the manufacture of turret clocks and church clocks. His works have never been subjected to the severe examination as to regularity of rate to which the chronometers of a maker competing for the Government purchase are subjected. He is enthusiastically fond of clockmaking, and is a good mechanic, but he has seen none but English clocks, and those principally in a limited district.

The clock required for the New Palace is necessarily very large, and I understand it to be the desire of the Commissioners of Woods and Works that it should be very accurate. There is no difficulty in combining these two properties; and I have in every communication with the makers proceeded on the tacit understanding that the accuracy of the clock is to be at least equal to that of an astronomical clock.

These requirements demand in the maker a combination of the two kinds of knowledge which separately distinguish Mr. Whitehurst and Mr. Dent.

If it were necessary to intrust the making of the clock, without any control, to one or the other of these two makers, I should prefer Mr. Dent; because I think it easier for Mr. Dent to acquire Mr. Whitehurst's solidity than for Mr. Whitehurst to acquire Mr. Dent's accuracy. But, under the most trifling control, either of these makers will certainly construct the clock in a perfectly satisfactory way.

3. On the plans which have been sent in.

I have had difficulty in obtaining explicit plans from Mr. Whitehurst. Mr. Dent's plans, it is understood, are not final. I have consented to receive them in this state; the labour and expense of preparing finished plans being so great that no maker ought to be required to furnish them except it is ascertained that he will be employed to make the clock, the general basis of the plans being fully understood.

Taking a basis of the last plans, and the last written communications of both makers, I am satisfied with either; and I have no doubt that the object of the Commissioners would be fully carried out by the adoption of either.

The question of attaching apparatus for effecting the regulation of other clocks by a magneto-galvanic current must, for the present, be kept open. The experiments which I have made lead me to doubt the practicability of this plan. There is no doubt that the regulation would be effected with perfect ease by means of a galvanic battery, but this is attended with various inconveniences.

The transmission of a signal to Greenwich by a magneto-galvanic current is a matter of no difficulty, and I recommend that preparation be made for it.

The effect of these considerations is almost purely to suppress the separate piece of clockwork in Mr. Whitehurst's letter of 15th March.

4. On the sums demanded by the makers for the construction of the clock.

These are :—

	£.
Mr. Dent (15th March)	1600
Mr. Whitehurst (15th March, omitting the sum of 150*l.* as applying to the separate piece of machinery)	3373

It is out of my power to explain fully the astonishing difference between these two tenders; but I think it likely to arise from two causes.

First. That Mr. Dent, who is a most skilful tradesman, is really able to do the work at less outlay than Mr. Whitehurst. It may be proper here to mention that Mr. Dent has, in his proper business, materially lowered the prices of chronometers.

Secondly. That Mr. Whitehurst has made his estimate at what may be called a "paying price," while Mr. Dent, who is one of the most enterprising of London tradesmen, has not, improbably, been willing to construct the clock at an actual loss to himself for the sake of the reputation which he hopes thereby to acquire.

If the question of cheapness (the plans being supposed equally good) be the only one which enters into the consideration of the Commissioners of Woods and Works, there can be no doubt that Mr. Dent's proposal ought to be accepted; but I am aware that other departments of the Government have sometimes judged it dangerous to be led solely by this consideration. It has come to my knowledge that tenders which proportionately were as low as Mr. Dent's have been rejected by the Admiralty.

In this state I must beg permission to leave the business in the hands of the Commissioners, as I do not consider myself competent to suggest to them a final decision. I enclose some remarks on Mr. Vulliamy's papers.

I have, &c.,

(Signed) *G. B. Airy.*

Royal Observatory, Greenwich,
May 18, 1847.

Sir,

I BEG leave to annex to my report of this date on the clock for the New Palace at Westminster, the following remarks on the papers by Mr. B. L. Vulliamy, which have been transmitted to me by the Commissioners of Woods and Works.

It is impossible for me to consider Mr. Vulliamy as a person who can be employed to construct the clock, he having decline to compete, except before a numerous Committee, and having objected personally to myself as a referee; but I think it due to the Commissioners who have transmitted the papers, as well as to Mr. Vulliamy's position and standing, that they should not be passed by me without remark.

The demand for a Committee is not borne out by the precedents which Mr. Vulliamy has cited. In the instances of Harrison, Arnold, Earnshaw, Mudge, &c., the question was on the introduction of principles which, when established, would be applied in an infinite number of instances, and which would bear powerfully upon the important subjects of commercial safety and national defence. No such things are concerned in the great clock; there is no new principle; the instance is unique; its effects are only those of the display of a good specimen of the present state of art.

The personal objection to myself is founded upon the circumstance that I had recommended Mr. Dent for the construction of the clock, which previous recommendation, in Mr. Vulliamy's judgment, disqualifies me as referee for competitors. I shall merely remark on this, that I not unfrequently, at the request of persons or bodies wanting chronometers, have indicated to them the chronometer makers whom I thought the best; that, concurrently with this, I do superintend and report on an annual competition of chronometer makers at Greenwich, and that there has never been a breath of complaint of unfairness in the judgment.

I trust it will be understood distinctly that I make these statements solely for the satisfaction of the Commissioners. To Mr. Vulliamy it ought to be sufficient answer that the Commissioners and Mr. Whitehurst (a *bonâ fide* competitor) have not the least doubt of the propriety of my decision.

I have very carefully examined Mr. Vulliamy's beautiful plans. In regard to the provisions for strength, solidity, power, and general largeness of dimensions, they are excellent. In regard to delicacy, they fail; and they fail so much, that I think myself justified in saying that such a clock would be a village clock of very superior character, but would not have the accuracy of an astronomical clock. I do not assent to the advantage of Mr. Vulliamy's peculiar pendulum suspension. I know that it would fail for a balance, or for a vertical-force magnetometer, and I believe that it would fail for a pendulum. I do not assent to the advantage of Mr. Vulliamy's turning pieces for pallets and hammer tails, believing that they will introduce evils more important than those which they are intended to remove. Mr. Vulliamy has entirely misunderstood a passage in Berthoud relating to chronometer springs, and has, in consequence, been very far misled in the immediate aim of some of his constructions.

I allude to these specific points, not for the purpose of making them subjects of discussion, but in order to convince the Commissioners that I have looked very carefully to the whole matter.

I have, &c.,
(Signed) *G. B. Airy.*

Office of Woods, &c., June 17, 1847.

Morpeth,
A. Milne,
Charles Gore,
} Commissioners of Her Majesty's Woods, Forests, Land Revenues, Works, and Buildings.

Before proceeding to make any remarks upon Mr. Airy's report, as contained in his letter to Mr. Milne, of the 18th May, 1847, it may not be amiss to make some inquiry as to his fitness for the position in which he desires to be placed.

There is no record, until the year 1843, of Mr. Airy's attention being directed to any but astronomical clocks, the construction of which is as different from that of public clocks as the uses for which they are intended. The great distinction is this, that the one merely indicates the time upon a single face, while the other shows the time upon an indefinite number of faces, and strikes the hours and quarters. The one is as well protected as it can be, while the other is exposed in every conceivable manner.

That Mr. Airy is strongly biassed in favour of Mr. Dent, is apparent in the whole of the proceedings. His first letter to Mr. Dent, in 1845, wherein he states that "*he shall without hesitation recommend him as the fittest person to be employed to make the clock*," amounts to a positive pledge to support Mr. Dent's pretensions. His advice to Lord Canning, that if Mr. Dent's estimate "*be not excessive, he should be employed without reference to any other maker*," is corroborative of the foregoing opinion. The same bias is shown in his letter to Mr. Gore, of 22nd September, 1847; wherein, "more in sorrow than in anger," he condemns Mr. Dent's withdrawal from the competition, and recommends his reinstatement; while, at the same time, he extinguishes the proposal of Messrs. Thwaites and Reed on a plea of expense which it was for Messrs. Thwaites and Reed, and not for Mr. Airy, to consider.

Mr. Airy, from the beginning to the end of his report to Mr. Milne, evinces the same partial disposition in favour of Mr. Dent; and his disinclination to admit a competitor

with him, is clearly visible. Mr. Airy admits that "*neither of the two candidates possesses within himself the necessary means to construct the clock, but must receive considerable assistance from a manufacturing engineer.*" The comparison he draws between the merits of the two candidates is not applicable. Mr. Dent has, for many years, turned his attention to making chronometers, and has very justly enjoyed the reputation of being an eminent chronometer-maker; but, as a maker of public clocks, he was almost unknown, until 1843, when, under the auspices of Mr. Airy, he undertook to make the clock for the Royal Exchange. Mr. Whitehurst, on the contrary, has, for many years, devoted his attention solely to clocks.

Mr. Airy further evinces his undue preference for Mr. Dent, by admitting Mr. Dent's plans in an incomplete state; for he says it is "*understood they are not final:*" yet, in the very same paragraph, he prejudices Mr. Whitehurst, personally, by saying that he had had difficulty in "*obtaining from him explicit plans.*" That the plans were, indeed, incomplete, is shown by the expression used concerning them by Mr. Dent himself, in the "*explanation of Drawing A.,*" dated 15th March, 1847, viz., "*the drawing now sent can only be considered as a mere sketch.*" This is probably the first time "*a mere sketch*" was ever offered under similar circumstances; or, if offered, accepted.

The difference in the amount of Mr. Dent's and Mr. Whitehurst's estimates, may, to a certain extent, be accounted for by the different modes of striking the quarters. Mr. Dent proposes the method by two hammers, while Mr. Whitehurst makes use of five hammers, by which the quantity of work, and, consequently, the expense, are increased.

Mr. Dent's repeated emendations of his specification are tantamount to three distinct specifications. In the first, he intended a clock on the same scale as that at the Royal Exchange, as is shown by his suggestion that a great saving of expense would be effected by employing the same patterns for the castings. Now, the first estimate (1500*l.*) was given with the first specification, and when it is remembered that 700*l.** was the contract price for which Mr. Dent undertook to make the Royal Exchange clock, including the chimes, dials, fixing, and all contingencies, it is, beyond doubt, that, for such a clock, 1500*l.* was a remunerating price. Mr. Dent gave a second specification subsequently, and, because even Mr. Airy detected that the clock would be too small, he consents that it shall be much increased in size, whereby it is reasonable to suppose that the cost of the clock would be considerably augmented; but for some reason, unexplained, Mr. Dent declares that he "*adheres to his original estimate.*" In the statement of dimensions which accompanies his "*Explanation of Drawing A.,*" Mr. Dent again makes it appear that he has considerably increased the size of the clock, and, finally, he proposes to make a clock of, probably, double the size of that at the Royal Exchange. Mr. Dent, nevertheless, "*adheres to his original estimate*" of 1500*l.*, with the addition of another 100*l.* for the magnetic machinery.

Something very similar occurred when the clock for the new Royal Exchange was contracted for; no fewer than six tenders were sent to Mr. Tite, the architect. The amount of Mr. Dent's was about half that of either of the other candidates; and when, in conformity with the given instructions, the candidates all attended at Mercers' Hall, on the 28th of July, 1843, Mr. Dent was the only candidate called before the Committee, who immediately accepted his tender; and on this occasion Mr. Airy is reported to have been present to assist the Committee with his advice.

Mr. Whitehurst gave in only one tender and estimate, which (as is shown by the dimensions of his wheels expressed in figures) was for a very large clock. The addition required by Mr. Airy for the electro-magnetic apparatus, did not alter the size of the clock, and the addition of 150*l.* to the cost, was occasioned solely by this additional work.

Mr. Airy next proceeds to make some observations upon Mr. Vulliamy's papers. His remarks on the cases of Harrison, Mudge, Arnold, and Earnshaw, which are cited by Mr. Vulliamy, may not be precisely applicable to the present case. There, probably, is not on record another exactly similar case to the present; but those instances prove the fact intended to be shown, namely, that the decision on the merits of the different claimants was not left to one individual, which is all that is contended for.

Mr. Airy's observations on Mr. Vulliamy's personal objection to himself are unfairly made. Mr. Vulliamy has never objected to him as a referee, though he has denied the

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* See Report of the Royal Exchange and Gresham Trusts Committee, 23rd January, 1845, page 92.

propriety of his being "sole referee," which is not surprising, if remembrance be retained of Mr. Airy's letter to Mr. Dent on the 22nd July, 1845, and of his other letter to Lord Canning on the 22nd June, 1846. Mr. Airy then refers to the rating of the chronometers sent to be tested at Greenwich. There is no analogy whatever between the rating of chronometers and the judgment upon the construction of this clock. All that is done at Greenwich with the chronometers sent for trial, is to carefully note their rates, which is done by Mr. Airy's assistants; the rates are the facts of the case, and decide of themselves the merits of the chronometers.

Mr. Airy is pleased to be facetious upon Mr. Vulliamy's plans, which he seems to think worthy of a village clock. But a village clock striking upon nine bells, of which the largest should weigh 14 tons, would certainly be something very extraordinary; though not more so than the assertion that it is practicable to make a clock, exposed, as the New Palace clock must be, and with four minute hands of the uncommon length of from 12 to 15 feet, measure time with the accuracy of an astronomical clock!

Upon Mr. Airy's remarks on Mr. Vulliamy's specification, it may be observed, that they are quite foreign to the question whether it is proper Mr. Airy should be sole referee in the matter of the proposed clock. It would appear that he already considers himself invested with that authority; for he commences his remarks, in his letter to Mr. Milne, by stating that "*It is impossible for me to consider Mr. Vulliamy as a person who can be employed to make the clock.*" Now, although Mr. Airy finds it impossible to consider Mr. Vulliamy as a person who can be employed to make the clock, the Commissioners of Woods and Forests have not signified that they have come to such a conclusion. As to the passage in Berthoud, which, Mr. Airy says, has been misunderstood by Mr. Vulliamy, it will necessarily lead to a long explanation, and will therefore be noticed in the Appendix.*

1847, May 3. No. 37.

Sir, 33, Cockspur-street, May 3, 1847.

I BEG leave to inform you, for the information of the Commissioners of Her Majesty's Woods and Forests, that as the Commissioners have done me the honour to admit me to compete for the large clock for the New Palace at Westminster, I have most respectfully to request that I may be informed if the Commissioners will be pleased to allow me to compete for all other clocks or time-keepers which may be required for the New Palace.

I have, &c.,

T. W. Philipps, Esq., &c. &c. (Signed) *E. J. Dent.*

1847, June 8. No. 38.

Sir, 33, Cockspur-street, June 8, 1847.

I BEG most respectfully to inform you that, on the 3rd ultimo, I addressed a letter to the Commissioners of Her Majesty's Woods and Forests, soliciting that the Honourable Board would be pleased to admit me as a competitor for all clocks required for the New Palace at Westminster, and not having received a reply, I take the liberty of again addressing the Honourable Board, fearful that in the multiplicity of papers my letter has been mislaid. Permit me, sir, to further state that I would not trouble the Commissioners had they not informed me in their letter addressed to me on the 10th December, 1845 (after admitting me to compete for the large clock), that "as well as for supplying any other clocks that may be submitted to competition."

I have, &c.,

T. W. Philipps, Esq., &c. &c. (Signed) *E. J. Dent.*

1847, July 3. No. 39.

My Lord and Gentlemen, 33, Cockspur-street, July 3, 1847.

I BEG most respectfully to inform your Honourable Board that on the 10th of December, 1845, I received a letter from the Commissioners of Her Majesty's Woods and Forests, granting my request to be admitted a competitor for the large as well as for supplying other clocks for the New Palace at Westminster. My impression was that all the clocks would be open to competition, but, to prevent any mistake, I addressed a letter to your Honourable Board to make inquiry, on the 3rd May, 1847, and not having been favoured by an answer, I took the liberty of forwarding another letter on the 8th of June, 1847; but to neither of these letters have I received any reply. Perceiving that several clocks are already in the House of Peers, consequently the arrangements for

* See Appendix No. 7.

supplying the clocks have taken a different course to what I anticipated when I addressed my letter to the Commissioners of Her Majesty's Woods and Forests of the 13th of November, 1845, I therefore most respectfully request permission of your Honourable Board to allow me to withdraw my name from the list of competitors for the large clock, and that your Honourable Board will also be pleased to order my drawings and papers to be returned.

I have, &c.,
(Signed) *E. J. Dent.*

Office of Woods, &c., July 15, 1847.

Morpeth,
A. Milne,
Charles Gore,
} Commissioners of Her Majesty's Woods, Forests, Land Revenues, Works, and Buildings.

1847, July 14. No. 40.

COPY of a LETTER from *A. Milne*, Esq., to Mr. *Dent*.

Sir, Office of Woods, &c., July 14, 1847.

ON behalf of the Commissioners of Her Majesty's Woods, &c., I have to inform you that since the receipt of your letters, dated respectively the 3rd of May last, the 8th ultimo, and the 3rd instant, no clocks have been ordered for the use of the New Houses of Parliament; that it appears, by a letter from Mr. Barry, he had, in October last, submitted an estimate of furniture, &c., required for the New House of Lords, which was subsequently sanctioned by the Treasury; that such estimate comprised sundry new clocks, which Mr. Barry has informed the Board he had ordered from Mr. Vulliamy, from his having great faith in him as a clockmaker, and being from experience and examination of opinion that the prices charged for the clocks he ordered are fair and reasonable.

I am to add that the Board has now signified to Mr. Barry their directions that no further orders for clocks be given without their previous sanction, and to acquaint you, that if, upon full consideration, it shall be determined to have any more clocks that may be wanted for the New Houses of Parliament supplied by tender on competition, the Board will include your name among those who may be applied to for such tenders.

With reference to the concluding paragraph in your letter of the 3rd instant, desiring to withdraw from being a competitor for making the great clock for the New Palace at Westminster, and requesting that the drawings and other documents which you have submitted for this purpose may be returned to you, I have in reply to state, that from what has already occurred, and pending the further inquiry into this matter, the Board would be unwilling at present to part with any of the plans or other papers connected with this subject, which have now become registered official documents in this office.

I am, &c.,
(Signed) *A. Milne.*

1847, August 4. No. 41.

Mr. *Dent* to the Commissioners of Woods and Forests.

My Lord and Gentlemen, St. Petersburgh, August 4, 1847.

I BEG leave most respectfully to inform your Honourable Board that I have this day received a letter, dated 1847, July 14th, from your Honourable Board, and as my correspondent does not state if he informed the Commissioners of my absence from London, I have now to request permission to acknowledge the receipt of the above letter.

When I addressed my letter to your Honourable Board of 3rd July, 1847, I was not in possession of the printed returns made by order of the House of Lords; I believe it was on the 5th July that his Grace the Duke of Richmond gave me a copy. From the contents of the official papers, also from the letter dated 14th July, 1847, I am induced to solicit from your Honourable Board that you will be pleased to allow me to remain as a competitor for the clocks required for the New Palace at Westminster, so that I may be in a position to correspond further on the subject with your Honourable Board on my return.

Perhaps, my Lord and Gentlemen, you will permit me to allude to one circumstance in the official papers called for by Lord Brougham. His Lordship moved in May, 1847, on the part of Mr. Vulliamy, for a copy of a certain letter accompanying my estimate, and which was delivered (as well as my memory serves me at this distance from my papers) to the Office of Woods and Forests in March, 1847; I therefore am of opinion that some person must have had access to the private official papers of the Office of Woods, &c., or that some indirect information was given, otherwise his Lordship could not have made this identical selection.

I have, &c.,
(Signed) *E. J. Dent.*

The assumption made by Mr. Dent, in the last paragraph of this letter, is as offensive and disrespectful to the Commissioners of Woods and Forests as the imputation which it casts upon the gentlemen in their Office is unjust and unwarrantable.

1847, August 20. No. 42.

Charles Gore, Esq., to Mr. *Dent*.

Sir, Office of Woods, &c., August 20, 1847.

I HAVE, on behalf of the Commissioners of Her Majesty's Woods, &c., to acknowledge the receipt of your letter of the 4th instant, and I have in reply to acquaint you that, agreeably to your request, the Board are willing that you should remain a competitor for making the great clock for the New Houses of Parliament, and should the Board deem it advisible to submit to competition any other clocks that may be required for the New Palace, they will not object to include your name amongst those that may be applied to for tenders.

With reference to the latter portion of your letter, I have further to acquaint you, that the information you refer to was given at this Office in consequence of an application addressed to the Chief Commissioner of this Board on the part of Lord Brougham.

I am, &c.,
(Signed) *Charles Gore*.

1847, August 17. No. 43.

Messrs. *Thwaites* and *Reed* to the Commissioners of Woods and Forests.

Clock Manufactory, 4, Rosoman-street, Clerkenwell,
My Lord and Gentlemen, August 17, 1847.

FINDING Mr. Dent has withdrawn his name as one of the competitors for the large clock for the New Houses of Parliament at Westminster, we beg most respectfully to solicit the favour of allowing us an opportunity of tendering, should it be put up to further competition.

We have had the honour to make several turret clocks for Her Majesty's Commissioners, all which are nothing more than good, ordinary, substantial clocks, and at *ordinary prices*. The clock for the New Palace at Westminster is, perhaps, to be the largest and most handsome clock in England.

We have been established upwards of *one hundred years*, and have made more than *three thousand* turret clocks, sent to all parts of the world. At the present time we have several clocks belonging to Her Majesty's Commissioners under our care; viz. the British Museum, Somerset House, Chelsea Hospital, Hyde Park Corner Lodge, several clocks in the house Whitehall Place. The clock at the Royal Stables, Windsor, we made five years since, and we believe has given satisfaction as an ordinary timekeeper.

My Lord and Gentlemen, should you be pleased to allow us to tender for this important clock we trust that our estimate will in every way meet with your approval; our object will be to make this the finest piece of mechanism ever placed in a tower, and that the performance should be equal, if not surpassing, any other public clock now in use; and at the same time we beg most respectfully to offer our humble apology for thus troubling.

We have, &c.,
(Signed) *Thwaites* and *Reed*.

1847, August 30. No. 44.

Charles Gore, Esq., to *G. B. Airy*, Esq.

Sir, Office of Woods, &c., August 30, 1847.

I AM, on behalf of the Commissioners of Her Majesty's Woods, &c., to transmit to you herewith copy of a letter, dated the 17th instant, which Messrs. Thwaites and Reed (clockmakers of Clerkenwell) have addressed to this Board, soliciting to be allowed to tender for making the great clock for the New Palace at Westminster. You will perceive that Messrs. Thwaites and Reed's application is founded on the supposition that Mr. Dent has declined to be a competitor; but as you are no doubt aware that he has subsequently expressed to this Board his desire to be allowed to withdraw his refusal to compete for the clock in question, I have to request you will favour the Board with your opinion, whether the admission of Messrs. Thwaites and Reed in the present state of the competition would be objectionable.

I have at the same time to acquaint you, that since the receipt of your reports, dated the 18th of May last, on the tenders and specifications, &c. then submitted, nothing further has been done by this Board regarding them, with the exception of furnishing the returns moved for by the House of Peers.

I am, &c.,
(Signed) *Charles Gore*.

1847, Sept. 22. No. 45.

G. B. Airy, Esq., to *Charles Gore*, Esq.

Sir, Royal Observatory, Greenwich, September 22, 1847.

I HAVE the honour to acknowledge your letter of the 30th of August, enclosing copy of a letter from Messrs. Thwaites and Reed, who, on the supposition that Mr. Dent has withdrawn from competition for the construction of the great clock for the New Palace at Westminster, are desirous of being permitted to offer tenders, and requesting my opinion for the consideration of the Commissioners of Woods and Works as to the propriety of receiving a tender from Messrs. Thwaites and Reed.

I beg leave, in the first place, to explain that I have within three days returned from Russia, and that this absence alone has caused the delay of my answer to your letter.

In reference to the question now laid before me, it appears to me necessary to decide, in the first place, whether Mr. Dent is to be considered as restored to his former status as competitor under the original terms of competition. His withdrawal was, in my opinion, a very ill-judged measure, and he forfeited by it any claim which he might have, and which might tend to influence the further proceedings of the Board. But if the Board are willing to consider him as restored to his former place, I see that much trouble will be avoided without positive injustice to any one, and I recommend, therefore, that he be considered as so restored.

If the Board shall view the matter in this light, then I think that the admission of a tender from any other person not named in the original applications for tenders is totally impossible. The expense, labour, and loss of time in preparing plans are so serious, that no person would undertake them without an understanding as to the extent of competition to which he was to be exposed. The number of competitors thus enters as a distinct element into the expectations which induce distinguished artizans to enter into the competition. I think that, considering the proceedings to have received no interruption from Mr. Dent's indecision, the public faith is engaged to admit no other tender.

I have, &c,
(Signed) *G. B. Airy.*

Mr. Airy's proceedings throughout this business are of a very extraordinary character, when it is remembered that, as "sole referee," it would be in his power to decide against the plans of any party who should venture upon a competition with Mr. Dent, his favourite candidate. It has been seen that he has already extinguished the pretensions of Mr. Whitehurst, and authoritatively rejected Mr. Vulliamy as a competitor. In the letter now under observation, his treatment of Messrs. Thwaites and Reed is consistent enough with his conduct towards the other parties. He will not even allow Messrs. Thwaites and Reed to put in a tender. His pretext for thus precluding a respectable and old-established firm from entering the lists is one which needs only to be noticed for its futility. Had Mr. Dent adhered to his original proposals, it would have been unfair to deviate from the understood conditions on which he undertook certain expense, and went through certain labour; but Mr. Dent had, of his own free will, withdrawn from the competition, and had no claim to be a second time admitted to it on the *same* understanding as at first.

1847, Sept. 27. No. 46.

Charles Gore, Esq., to Messrs. *Thwaites* and *Reed*.

Sirs, Office of Woods, &c., September 27, 1847.

I AM, on behalf of the Commissioners of Her Majesty's Woods, &c., to acknowledge the receipt of your letter of the 17th ultimo, soliciting to be allowed an opportunity of tendering for the great clock proposed to be constructed for the New Houses of Parliament, on the supposition that Mr. Dent has withdrawn from the competition; but as you are under a misapprehension on this point, and the competition remains precisely as it was previously to your application, the Board cannot, under existing circumstances, receive a tender from you.

I am, &c.,
(Signed) *Charles Gore.*

1847, Sept. 22. No. 47.

G. B. Airy, Esq., to *Charles Gore*, Esq.

Sir, Royal Observatory, Greenwich, September 22, 1847.

IN the course of correspondence relating to the great clock for the New Palace at Westminster, I have several times adverted to the practicability of employing the spare power of the large clock to excite a magneto-electric current, by means of which many or all the smaller clocks in the palace could be kept in motion simultaneously with the large clock. In my last allusion to this subject, however, I expressed a doubt (founded on my own experiments) as to the practicability of effecting this.

In a late stay at St. Petersburgh, I had an opportunity of seeing experiments by Mr. Jacobi, which convince me that this proposal is perfectly practicable, at any rate to such an extent as to make it desirable that the question of adopting it should be entertained.

For my guidance in any further proceedings it is necessary that I should understand whether the Board of Woods and Works have so far decided upon the supply of smaller clocks as to prevent the application of this principle; and I would therefore request that you would have the goodness to inform me whether the arrangements of the Board do yet leave an opening for the introduction of the constructions to which I allude.

I have, &c.,
(Signed) *G. B. Airy.*

APPENDICES.

Appendix No. 1.

Copy of Mr. John Whitehurst's Letter to Messrs. Parkinson and Frodsham.

Gentlemen, Derby, August 4, 1843.

When I had the pleasure to see you last Saturday in London, I informed you it was my intention to write to the Astronomer Royal, G. B. Airy, Esq., F.R.S., and let him know how very unhandsome Mr. E. J. Dent, 82, Strand, had behaved to me, respecting the clock and chimes for the New Royal Exchange; but before so doing I wish to lay before you the particulars, and any advice or information you or your friends can impart (more particularly Mr. Vulliamy) to me on the subject, I shall gladly receive.

Last summer, Mr. Dent called on me, and went through my clock manufactory; he expressed himself highly pleased, particularly with my turret-clock work. He said he had seen a deal of turret work, but never had seen any so good before, nor anything like it; and that he should give me an order for a turret-clock, for the front of his new establishment; he had a turret-clock made by a person in London, which gave great dissatisfaction, and that he would have no more of him, and that I should make all the turret-clocks he wanted in future. I sold him some small clocks.

On my return from Bray, where I had been erecting a new church clock, in August last, I called on Mr. Dent, when he told me that the turret-clock he had formerly mentioned to me, and which clock Mr. Payne made for him, had got him into great disgrace. *Turret-clocks he did not in the least understand; they were quite out of his line*, and that he would not in future take an order for one on his own account; but what business came to him in that line he would recommend to me, for my own entire benefit, without any fee or reward to him in any shape; but to do the best for myself. He was completely sick of the Clerkenwell clockmakers, and would give me every support in his power, and recommend me wherever he had an opportunity.

In October last I received the following letter from him:—

Dear Sir, 82, Strand, October 28, 1842.*

I was consulted on the making of the Royal Exchange clock, when I gave it as my opinion that you should be written to in preference to any other maker, and I wish you every success.

Remember that I will not accept of any remuneration should you succeed.

Truly yours,

Mr. Whitehurst. (Signed) *E. J. Dent.*

On July 20th last, 1843, I received a notice dated on the 19th, from Mr. Tite, the architect for the New Royal Exchange, stating that I was at liberty to tender for a new clock and chimes for the Royal Exchange, and that a section of the tower, and a specification of what is required may be seen at the office of the Clerk of Works, on and after Friday, the 21st. In consequence of this notice, I immediately left home for London on the 20th; saw the section of the tower, and the specification on the 21st, and only Mr. Tite on the 22nd, who received me very politely. I made several suggestions to him, which he took notice of, and made some alterations in the specification from my suggestions. He informed me that the Astronomer Royal, Professor Airy, had spoken very kindly of me to him in consequence; he had made application to me from the Professor's recommendation. I said I thought it my duty to go to Greenwich, and thank the Astronomer Royal for his kindness. Mr. Tite said he was from home, and recommended me to write to the Professor, which I did when I returned home.

On the 21st of July I received another letter from Mr. Dent, of which I send you a copy as under:—

Dear Sir, Brighton, July 21, 1843.

I have just arrived here from Paris, and find waiting my arrival a notice from the Committee of the Royal Exchange, to offer an estimate, &c. for a chime-clock for the new building. Do me the kindness to write me if you have had a similar notice, as from what I said I suppose you have; and if so, will you state the amount of your estimate, &c. to me, as I am of opinion it will rest between† Vulliamy, yourself, and me. Your not residing in London will perhaps be an objection to you, which we would arrange together. I shall be at home on Monday morning; but at present I am so unwell from sea-sickness that I cannot proceed to London.

Truly yours,

Mr. Whitehurst. (Signed) *E. J. Dent.*

P.S. Please answer by return of post.

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* This is the same date as Mr. Tite's report, in which mention is made for the first time of a clock for the New Royal Exchange. See pages 89, 90, and 91 of Report of the Royal Exchange and Gresham Trusts Committee, 23rd Jan., 1845.

† If Mr. Dent possessed any information on the subject, he must have known that Mr. Vulliamy had declined, both verbally and by letter to Mr. Tite, the architect, to tender, to be employed, or, in fact, have anything whatever to do with the clock proposed for the new Royal Exchange.

This letter of Mr. Dent's very much astonished me after receiving so many professions of his regard for me. I merely replied to the letter, having received it; but of course did not name the amount of my estimate.

I went to London on the 27th, in order to deliver my propositions and tender on the 28th, agreeable to the request in my notice from Mr. Tite of the 19th. I attended at Mercers' Hall at the time appointed to deliver my specification and estimate to the Committee, where I met Mr. Dent, who told me the time was too hurried to make out the specification and estimate, and there was not sufficient time allowed to complete the clock and chimes, and with a significant nod said, "You will be the person employed."

It has been a great loss of time and expense to me to make out my tender, &c., and the journeys to London and back. I must say Mr. Dent has behaved in a very unhandsome manner to me, and I think the Committee ought to pay me for my time and trouble. I beg to lay this statement of facts before you, and hope to hear from you soon, that I may write to the Professor. I cannot sit down quietly with such behaviour as Mr. Dent's to me.

I have this day received a letter from Messrs. B. B. and J. Moore, 38, Clerkenwell Close, upon the subject. I have taken the liberty of referring them to you, that they may see this letter, and you have also my full authority to show it to any person you may think proper.

You must suppose I thought it very strange when I heard that the Committee had accepted Mr. Dent's estimates, &c.

I remain, Gentlemen,
Yours very respectfully,
(Signed) JOHN WHITEHURST.

To Messrs. Parkinson and Frodsham,
4, Change Alley, London.

APPENDIX No. 2.

MANY persons have been led to conjecture, from the observations which Mr. Airy has made upon Mr. Vulliamy's private character, that some personal misunderstanding had taken place between them, whereas they were utter strangers to each other until March, 1847, when, in consequence of a reference being made to the clock at the Post Office, Mr. Vulliamy was requested by the Office of Woods to show the clock to Mr. Airy, which he did in the presence of Mr. Charles Frodsham. Upon that occasion a correspondence, of which the following is a copy, took place between Mr. Airy and Mr. Vulliamy. This is the only occasion on which any communication of any sort has taken place between them.

No. 1.

Mr. *Vulliamy* to Mr. *Airy*.

Sir,

Pall Mall, March 10, 1847.

As you have taken the trouble to go to Derby to see Mr. Whitehurst's clock, I trust you will not refuse me the favour to go to Windsor to see the great clock I made for the Castle. This clock is much more to the purpose, in reference to the clock for the new Houses of Parliament, than the clock at the Post Office, or any clock I am acquainted with, except the clock I made for Cremille, near Plymouth.

I am, Sir, your most obedient Servant,
(Signed) *B. L. Vulliamy.*

J. B. Airy, Esq.

P.S. If you recollect, I asked you to do me the favour to go to see the clock at Windsor the day we met at the Post Office.

No. 2.

Mr. *Airy* to Mr. *Vulliamy*.

Sir,

Royal Observatory, Greenwich,
March 11, 1847.

I HAVE received your letter of the 10th, and, in reference to this subject, I beg to lay before you the following remarks:—

You are aware that when the Board of Works consulted me in the first instance, in relation to the construction of the clock for the New Palace at Westminster, I made mention to them of your name, as well as of those of Mr. Dent and Mr. Whitehurst. The first paper, however, which I received from the Board was a letter from you, dated August 29, 1846, in which you positively decline to act under my superintendence.

In a letter of the date January, 13, 1847, you repeated this refusal under a milder form.

Messrs. Dent and Whitehurst have expressed their perfect willingness to comply with this condition.

Now, it must be evident to you, that if your resolution on this point remain unshaken, there can be no use in my going to see the clock at Windsor. As you had transmitted a paper regarding the Post Office clock, I was anxious to show my respect to your personal position, and to prove my desire to neglect nothing which the Board thought worthy of notice, by making myself acquainted with it, and there was no difficulty depending on

the expenditure of time. But the loss of time in going to Windsor is to me a serious matter; and as, so far as I can perceive, it could lead to nothing whatever as regards the business before us, I think it best not to go. This has no relation to my own feelings of curiosity; whenever I shall be near Windsor I should be very glad, if possible, to have an opportunity of seeing the clock.

If you have in any degree modified in your own mind your resolution to resist my interference, it would give me very great pleasure to learn this from you. I would refer you to the Board of Works for copies of other papers which I have thought it necessary to send to the Board, and of which copies have been sent to Messrs. Dent and Whitehurst.

I am, &c.,
(Signed) *G. B. Airy.*

No. 3.

Mr. *Vulliamy* to Mr. *Airy.*

Sir, Pall Mall, March 11, 1847.

It quite escaped me in my note of yesterday to add that it will give me much pleasure to take you to see Mr. Robinson's manufactory at Pimlico, where I have the greater part of my large work executed under my immediate direction and inspection. An inspection of this place will, I am sure, satisfy you that it affords capabilities far exceeding those of any clockmaker in this kingdom.

I am, &c.,
G. B. Airy, Esq. (Signed) *B. L. Vulliamy.*

No. 4.

Mr. *Airy* to Mr. *Vulliamy.*

Sir, Royal Observatory, Greenwich, March 11, 1847.

I am obliged by your offer of facilitating my inspection at Bramah's works. I am, however, already acquainted with them, having transacted various business with Bramah and Robinson.

I am, &c.,
B. L. Vulliamy, Esq. (Signed) *G. B. Airy.*

No. 5.

Mr. *Vulliamy* to Mr. *Airy.*

Sir, Pall Mall, March 12, 1847.

I beg to acknowledge the receipt of your letter of yesterday's date.

Entertaining the high opinion I do of your abilities and acquirements, you should have considered my two letters addressed to Mr. Barry and the Office of Woods as wanting in courtesy to yourself. It would afford me much satisfaction and pleasure to profit by your assistance upon this or any other occasion, but what I object to is the principle of submitting a matter of this importance to the decision of any one individual, however great his attainments, and more particularly after that individual has pronounced so unqualified an opinion in favour of another as you have done in the case of Mr. Dent's clock at the New Royal Exchange, which you have reported to be in your opinion the best in the world. You have also, in a letter addressed to Mr. Dent, stated that if you were applied to on the subject, you should unhesitatingly recommend him as the most proper person to be employed to make the clock for the New Houses of Parliament. Upon the strength of this communication he has told parties who have repeated it, that he was to make the clock for the New Houses of Parliament. Under these circumstances I can come to no other conclusion than that you have virtually prejudged the question. But I am perfectly willing to compete if the question is left to the decision of a committee, of which so far from objecting, I should particularly wish you in your capacity of Astronomer Royal to be one.

I am, &c.,
G. B. Airy, Esq. (Signed) *B. L. Vulliamy.*

No. 6.

Mr. *Airy* to Mr. *Vulliamy.*

Sir, Royal Observatory, Greenwich, March 13, 1847.

I have to acknowledge the receipt of your letter of yesterday.

In my letter of the 11th there was no imputation against you of want of courtesy towards myself. I beg of you to read the letter again, when you will find that there is not the least insinuation of want of courtesy. I have only wished to call your attention to the fact that you had distinctly protested against the arrangement under which the competition of artists is received by the Board of Works, and that therefore it would be useless for me to expend valuable time in making the inspection which you suggested.

It is not my business to discuss whether the Board of Works have done well in intrusting this matter to one person.

With respect to the conclusion, "that I have virtually prejudged the question," it is sufficient for me to state that neither the Board of Works nor Mr. Whitehurst (a bonâ fide competitor), both of whom are cognizant of

my own opinions and actions in regard to Mr. Dent's performance, has come to that conclusion. I know nothing whatever of Mr. Dent's statements to other parties to which you allude.

I repeat that it would give me pleasure to understand that you are a competitor on the same terms as the other makers to whom the Board applied for tenders.

I am, &c.,

B. L. Vulliamy, Esq. (Signed) *G. B. Airy.*

Appendix No. 3.

Something similar to what is here proposed was done in the case of a clock made by Mr. Smart, A.D. 1830, for Grosvenor Chapel, in South Audley Street. The following are extracts from the Specification by which this clock was made:—

Extracts from Mr. Smart's Specification.

To prevent the force of the wind on the external hands from having any influence on the movement, the dial-works to be detached therefrom, and made to go with a separate power, and so peculiarly constructed that this power shall not communicate with the watch part.

The dial part, great wheel, and pinion, to be in all respects similar to those of the watch part, and run in brass bushes, and going fuzee continuing power to the same.

In reply to a recent inquiry, the following answer was given—"The detached motion work has been taken away, in consequence of its failing to perform accurately."

(Signed) Alexander Smart.

Chapel Street, Grosvenor Square, March, 1848.

Appendix No. 4.

As follows is a list of some of the clocks in the metropolis that strikes the quarters upon four bells:—

Churches.

Bow, Cheapside.	St. Lawrence.
Poplar.	St. Clement's, Strand.
Shoreditch.	St. Bride's, Fleet-street.
Cripplegate.	St. Dunstan's.
Bishopsgate.	Islington.
St. James's, Clerkenwell.	St. Margaret's, Westminster.
St. Sepulchre's.	

The number of clocks that strike the quarters upon two bells is too numerous to be mentioned.

Appendix No. 5.

The Act of the 12 Queen Anne, offering a reward of 20,000*l.* for the means of discovering the longitude at sea, was passed A.D. 1714. One of the first persons who applied for the reward was John Harrison; and a long account of the proceedings which took place is to be found in a 4to. pamphlet, dated February, 1763, entitled, "A Letter to the Right Honourable ***** Member of Parliament." From the appendix to this letter it appears that various communications took place between Mr. Harrison, the Royal Society, the Board of Longitude, and the Admiralty; and that on no occasion was the decision of any matter connected with Mr. Harrison's claim committed to a single individual. At a meeting of the Board of Longitude, 9th February, 1765, it was unanimously determined that the performance of Mr. Harrison's time-keeper had been such as to entitle him to the proffered reward; but it was resolved that, until certain conditions had been complied with, only 10,000*l.* should be paid.

It was part of Mr. Harrison's agreement to take to pieces and explain the principles and construction of his time-keeper. This he did on the 22nd August, 1765, in the presence of the following gentlemen, who had been appointed by the Board of Longitude, and of the Rev. Mr. Maskelyne, who insisted on having a right to attend, as being a Commissioner:—

John Mitchell.	Thomas Mudge.
William Ludlam.	William Mathew.
John Bird.	Larcum Kendal.

It was not till the year 1773 that Mr. Harrison succeeded in obtaining an Act of Parliament for payment of the remaining 10,000*l.* Harrison was born in 1693, and died in 1776.

In June, 1793, a claim for a reward for improvements in chronometers having been made by Mr. Mudge, and opposed by the Board of Longitude, it was brought by petition before the House of Commons, and referred to a Select Committee, consisting of the following members:—

Mr. Pitt.	Sir George Shuckburgh.
Mr. Wyndham.	Mr. Ryder.
Sir Gilbert Elliot.	Mr. Bragge.

This Committee called in to their assistance a Sub-Committee, as follows:—

The Bishop of St. David's.	Mr. Troughton, mathematical instrument maker.
Mr. De Luc.	Mr. Holmes, watchmaker.
Mr. Attwood.	Mr. Haley, watchmaker.
Mr. Ramsden, mathematical instrument maker.	Mr. Howells, watchmaker.

The Committee reported favourably to the House on Mr. Mudge's claim, and he received 3000*l.*

Subsequently Mr. Arnold and Mr. Earnshaw applied for the rewards offered for the discovery of the longitude. The claims of the rival candidates were very warmly supported; the first by Sir Joseph Banks, the second by Dr. Maskelyne. The whole matter was brought before the Board of Longitude; no decision of a single individual was permitted. Ultimately Messrs. Arnold and Earnshaw received each 3000*l.*

The great desire of the Board of Longitude to obtain all the information possible on this occasion is shown by the following circular, being a copy of the one addressed to Mr. Dalrymple:—

"Sir, "April 26, 1805.

"HAVING been desired by the Board of Longitude to place the annexed specification of Mr. Arnold in "the hands of persons, in my opinion, able and willing to suggest such questions as may tend to the better and "more perfect explanation of the principles of the time-keepers described therein, I forward to you a copy, "requesting that you will suggest, in writing, on the blank part of each page, such questions as you think likely "to produce explanatory answers for that purpose, and return the copy, with your questions, to Mr. Gilpin, the "Secretary of the Board of Longitude, at the apartments of the Royal Society, Somerset Place, on or before the "last day of May next.

"I am, Sir, your very humble servant,

"A. Dalrymple, Esq. "*Jos. Banks.*

"P.S. I also request that you will be good enough to note particularly every article which you consider to be "a new invention, as a thing unknown to the trade till it was communicated by this explanation, and how far, in "your opinion, each of these is an improvement likely to be advantageous to the public, either by rendering "time-keepers more accurate in their performance or less costly to the purchasers."

This letter, with all the papers connected with it, is in the library of a well-known collector of books and pamphlets on the subject of horology.

APPENDIX No. 6.

There are several public clocks in Flanders which have very large dials; but these only indicate the hours and the quarters by one hand, which makes a revolution in 12 hours: indeed, this was the only mode by which, until very recently, the time was shown by public clocks. These dials are not inaptly called skeleton dials, being composed of very light circles connected together by the figures and other divisions and slender bars traversing the centre, and are fixed in their places by fastenings not perceptible at a little distance. By this means the sight of the building is very little interrupted, or its general appearance disfigured. It must be borne in mind that when these buildings were erected clocks were almost unknown, and that not any provision being made for a dial, the general appearance is much disfigured by a large dial as commonly made. Of this there cannot be a more striking example than is exhibited by the clock tower of Canterbury Cathedral, which is sadly disfigured by the clock face. In modern buildings, when it is intended to place a clock, it is customary to provide for the dial. The largest skeleton dial in Flanders is the dial of the clock in the great tower of the cathedral at Malines: it is 42 Flemish* feet in diameter, but from its great height and the great size of the tower, the sides of which measure 90 feet at its base, it does not appear nearly so large. In the centre of the place the exact size of the dial, of the figures, and all its parts, is represented in the pavement by a species of very coarse mosaic composed of dark stones.

APPENDIX No. 7.

Upon this passage in Berthoud, which Mr. Airy asserts "Mr. Vulliamy has entirely misunderstood," no other construction can be put than that which is given to it in Mr. Vulliamy's specification, enclosed in a letter to Mr. Barry, dated 29th August, 1846. The text in Berthoud is as follows—("Traite sur les Horloges Marines." Paris, A. D. 1773, page 86):—

"253. Ce troisième effet, plus puissant que les deux premiers, appartient aux changements que le chaud et "le froid causent à l'élasticité du ressort, et independamment du changement que la chaleur opère dans sa "longuer, elle relâche encore le ressort, et lui fait perdre de sa force élastique. Le froid, au contraire, en "resserrant les pores du ressort, en augmente la force élastique. C'est un fait que nous devons à l'expérience:

* A Flemish foot is equal to about 12·37 in. English, which gives 43 ft. 2·7 in. for the diameter of the dial, English measure.

" quant à la cause, ou aux causes, qui le produisent, j'en abandonne à ces philosophes heureux pour qui la nature " n'a rien de caché."

" 254. Quoi qu'il en soit, il est évident, d'après ce que nous venons d'exposer, que la durée des vibrations " d'une Horloge Marine est augmentée par trois causes lorsqu'elle est exposée à la chaleur: 1°. Par l'aug- " mentation du diamêtre du balancier; 2°. Par l'alongement du ressort spiral; 3°. Par la perte de sa force " élastique. Nous allons chercher les moyens de compenser aussi parfaitement qu'il est possible les effets du " chaud et du froid."

The above forms part of a long article commencing 247, page 84, upon the effects resulting from heat and cold upon the going of a marine chronometer. The two first results, from change of temperature, are, according to Berthoud, the increase and diminution of the diameter of the balance, and the lengthening and shortening of the pendulum spring. Now he shows, by calculation and experiment, that a compensation for heat and cold applied to the pendulum spring of a chronometer, must, to correct the going of the watch, lengthen and shorten the spring very much more than the quantity given by the calculation for the difference in the diameter of the balance and the length of the pendulum spring, and that the necessity for this additional compensation is to be found in the increase and diminution of the elastic force of the spring.

The same theory is applicable to the suspension spring of the pendulum of a clock. Whatever compensation is applied to the pendulum must compensate for the lengthening and shortening of the rod, and for the variation and flexibility of the spring as stated in Mr. Vulliamy's specification.

Mr. Dent, some time since, in a lecture at the Royal Institution, claimed the merit of this discovery, as applicable to the pendulum spring of a chronometer, and Mr. Cooper, more recently, in a lecture on Horology, at the Westminster Scientific Institution, also claimed it for him. This gave rise to a correspondence between Mr. C. Frodsham and Mr. Cooper, and Mr. Vulliamy and Mr. Cooper, which ended by the latter admitting the mistake he had inadvertently fallen into of attributing the discovery to Mr. Dent.

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